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AN AUTOMATIC AËRATING DEVICE FOR AQUARIA

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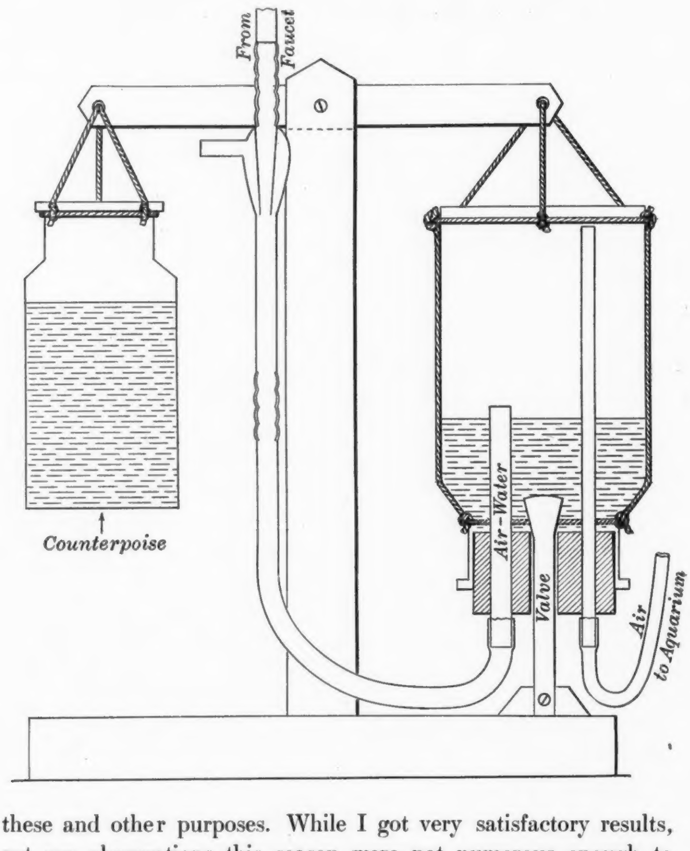
The use of the water blast as a means of aërating is well enough known to need no more than passing mention. Its cost is prohibitive for smaller schools and its use limited to laboratories where noise would not be a disturbing factor. Furthermore it may be desirable to have an aquarium under observation in different rooms. Some time ago a simple device was described (*Amer. Nat.*, vol. 38, no. 453, 1904, pp. 655–661, 2 figs.) which, however, necessitates the exchange of the water in the aquarium. This might involve the loss of organisms if the flow were continuous as from a tap, or it would necessitate lifting the water periodically.

These were some of the difficulties I encountered when about a year ago I wished to aërate some small aquaria containing sea water, in a class room where fresh water was available, but a flow of sea water could not be had. An ordinary filter or vacuum pump was fitted into a calcium-chloride jar about 45 cm. tall. The accumulating air in the jar was carried through the stopper by a small tube to the aquarium. A ball valve of paraffin held against the lower opening of the jar by a lever and weight was to regulate the outflow of water. This and similar devices tried, failed to regulate the varying pressure in the supply pipes, and was not satisfactory. If regulated for the day when more taps were in use, the pressure increased during the night, with few or no other taps on, so that the fresh water overflowed through the air tube and diluted the sea water.

The above obstacles were entirely overcome in a device that I hit upon the past summer at the Marine Biological Laboratory

Woods Hole, in attempting to aërate the sea water in which Gonionemus was kept, rather than to use the water from the pipe. Other workers have carried water daily from the end of the pier to get more favorable results than with the water from the pipes. It remains to be seen whether aëration and cooling will answer



these and other purposes. While I got very satisfactory results, yet my observations this season were not numerous enough to warrant any general claim for all-around usefulness.

A general idea of the apparatus may be gained from the figure. The things needed are a glass filter pump, two wide-mouth bottles, about 8 × 15 cm., and 6 × 12 cm., a cork stopper to fit the larger

bottle, a stand with balance beam, glass and rubber tubing. The stopper is bored with three holes, 5 mm., 8 mm., and 11 mm. in diameter. Into the smaller holes are fitted a 24 cm. long tube for the air outflow and a 15 cm. long tube for carrying the water from the filter pump. The 11 mm. hole is for a wooden rod, 15 mm. in diameter and about 15 cm. long. This is cut down tapering abruptly from 15 mm. to 8 mm. the rest of its length. The larger end of this rod serves as a valve in the 11 mm. hole in the stopper being placed vertically so that the stopper can glide freely along the rod when placed in the inverted bottle.

A few details will be desirable for those who wish to try the apparatus. After inserting the glass tubes as shown in the figure, the wooden rod is inserted through the stopper from the side that goes into the bottle. Then the small end of the rod is attached to a block. Now the larger bottle is suspended in inverted position from one end of the balance beam of the stand, the stopper is inserted and the smaller bottle nearly filled with water is hung on the opposite end of the beam for counter-poise. The block carrying the wooden rod is moved about on the base of the stand until the stopper moves easily up and down the rod, and is then fastened in this position with a wood screw. The length of the cord supporting the inverted bottle should be so adjusted that the beam on this side is a little higher than on the opposite side when the stopper is drawn up against the head of the wooden rod as far as it will easily go. If the head of the rod fits the hole in the stopper accurately no water will escape when it is turned on until the weight of water in the inverted bottle exceeds that of the counterpoise. Now the weight of the counterpoise may be adjusted so that it will keep the larger bottle about $\frac{1}{3}$ full of water, thus preventing the escape of air except through the proper outlet. The water and air should not discharge alternately and if this does take place, a longitudinal groove may be cut into one side of the head in the stopper until enough water escapes to balance the inflow when the water pressure is at its lowest. From this on it will work automatically. Several other forms of valves may be used but I have found the one described the simplest.

If it is desired, more than one aquarium may be aërated with the same apparatus by dividing the air with T-tubes and using

pinch cocks until the desired flow is obtained in each, necessitating, however, more attention than the simpler form. The main features of this apparatus are: its automaticity, its noiseless action making it suitable for the class room or laboratory table, its simplicity and inexpensiveness.

Detroit, Mich.

THE FLYING-FISH PROBLEM[1]

LIEUT.-COLONEL C. D. DURNFORD

In a paper published in the *Annals and Magazine of Natural History* for January, 1906, the impossibility, from a mechanical point of view, of a flying-fish accomplishing sailing flight was shown. The argument was based upon the fact that as a flying animal the flying-fish is equipped with wings of a fractional sailing value compared with those of a sailing bird. Also that if the wings were many times larger, so as to bring the fish on an equality with the bird in this respect, it could only sail with the bird's limitations as regards direction of the wind, and with the bird's frequent assistance from rowing flight. Also that if the figures (which can be easily verified or, if wrong, refuted) are correctly given in the article, the accepted aeroplane flight is miraculous, unless a new law of Nature be discovered.

It is, then, perhaps advisable, if the present curious condition of the question is to be understood, to examine how it has come about.

The flying-fish problem is a very odd one in many ways, of which the most striking is the unexplained power therein of the negative to quench the positive. Throughout we find the aeroplanist's "I cannot see the wing-movement" smothering a fairly equal bulk of "I can, and have, and do see it."

Let us create a parallel instance, for a real parallel does not perhaps exist: — Many people can see bullets in their flight. Many others with equally good, or even better, sight cannot pick up the flying bullets. Now if those who fail to see them said, and if all books and papers on shooting supported them in so saying,

[1] This article was intended to appear simultaneously in the *American Naturalist* and in the Annals and Magazine of Natural History but delays in the mail prevented. The subject however is of such interest that its later publication here may be pardoned.—EDITOR.

"I cannot see the bullets, therefore you, and all those who do see them, do not see them," we should have a parallel to the current odd mode of conducting the flying-fish problem.

It is in consequence of this supremacy of the negative that the flying-fish problem has earned for itself the name of "eternal," for as soon as one new witness can see the flight, either another new one fails to do so, or a reference is made to some observer who has formerly so failed; and this is equally satisfactory, for, in the problem, even an old "I did not" is better than a new "I do."

It might naturally be supposed that there must be an overwhelming backing of probability, both mechanical and natural, to the negative evidence in order to justify such dogged denial to the affirmative of its common value. So far, however, from this being the case, it is a second odd fact that but one seemingly practical effort at proof has been made, and with this one exception aeroplane flight rests wholly upon the flat negative.

Let us examine this solitary attempt at proof.

I requote from an article, which may be taken as typical of the system, in the 'Annual Report of the Smithsonian Institution,' 1904, p. 498, by Dr. Theodore Gill, an emphatic aeroplanist: — "Möbius (1878, 1885) contended that 'Flying-fish *are incapable of flying* [the italics are his], for the simple reason that the muscles of the pectoral fins are not large enough to bear the weight of their body aloft in the air.'" If undisputed that is, without doubt, a most powerful argument — decisive, in fact. But mark! almost immediately Prof. Whitman, a high authority, denies its accuracy. In the same article we find that this statement is "vigorously objected to by C. O. Whitman (1880), who urged, 'Admitting that in form, size, length, and structure the pectoral fins of *Exocœtus* are less well adapted to flight than the wings of most birds, there is still ample room to believe, on anatomical and physiological grounds alone, that they are capable of executing true flight.'" This is a plain statement moderately worded by a distinguished physiologist and naturalist, and it is interesting to note that it is answered, as though by convincing argument, by the old irritating *impasse* — the reference to views of distinguished naturalists as to whether flying-fish fly or do not fly, and entirely ignoring the new muscle aspect opened by Whitman.

Among the distinguished naturalists thus referred to in support of Möbius's theory, Prof. Moseley, as being of the 'Challenger' Expedition, and Mr. Boulenger are prominently mentioned. But Moseley, who cannot see the *Exocœtus* flapping, can see the Dactylopterids doing so (p. 512): the possibility of which act is denied by Möbius from personal observation as strongly as in the case of *Exocœtus!* Whilst Boulenger merely quoted the verdict of others, he himself retained, then as now, as he informs me, an open mind upon the question.

It is surprising how largely this "general verdict" is influenced by the researches of Möbius, the very Professor whose solitary so-called proof is questioned by Whitman; so we will examine more closely what he says about the muscles. The quotation is continued from "'aloft in the air,'" above.

"'The pectoral muscles of birds depressing their wings weigh, on an average, one sixth of the total weight of the body, the pectoral muscles of bats one thirteenth, the muscles of the pectoral fins of flying-fish only one thirty-second.'"

If this proves anything — which to the purpose it does not — it may prove that, as flying-fish have somewhat less than half the comparative muscle of bats, and (according to aeroplanists) cannot, for this reason, fly, therefore bats, which have somewhat less than half the comparative muscle of birds, cannot fly.

Or, the other way about: — Birds can fly. Bats, having rather less than half the comparative muscle of birds, can fly; therefore flying-fish having rather less than half the comparative muscle of bats, may fly.

Those are reasonable deductions, but "therefore flying-fish cannot fly" is an unreasonable one.

It is quite clearly a question of degree, and the true deduction is that bats, if they can fly, cannot be expected to fly like birds, and flying-fish, if they can fly, cannot be expected to fly like either bats or birds; and, I may add, no one thinks or claims that they do so fly.

But an even greater claim is made by aeroplanists. It is recognized that there are two kinds of bird-flight, "sailing" and "rowing," the sailing being greatly the superior form. Sailers can always row, but rowers cannot properly sail on account of their low wing

to weight ratio.[1] Now flying-fish have a ratio of the lowest class in comparison with birds (see 'Annals,' Jan. 1906, p. 162); yet they are credited by aeroplanists with sailing of a higher form than that of the best-equipped sailing birds — sailing, without even occasional rowing assistance, at a slow speed, regardless of the direction of the wind ! Such a feat — one utterly impossible for an albatross,[2] an eagle, a vulture, kings of flight — is given to this last poor dabbler in the art upon persistently contradicted negative evidence, two impossible parallels, and the one discredited proof.

I have endeavored in the foregoing to show how observers have been weighted and clogged by the unique system of handling an admittedly difficult question — how a very able man, Prof. Möbius, years ago undertook a research which required a very special knack of eyesight in the observer. Probably the majority of men are without this knack, and do not know it. Firmly believing what I have endeavored to show must have been the false view presented to his retina, to be a true view, he wrote, with the cleverness that belonged to him and the dogmatism of the believer, the text of the faith which has guided and misguided scientists for over a quarter of a century. His reputation was, and is, deservedly great — so great that his word was practically law, and it came about that if other scientists possessed the knack of sight and differed from him so much the worse for them; they must be either ignored, or explained away, any or no explanation being sufficient for such a proper purpose. This is not a hard judgment. Anyone, who is free from the superstition, on reading an ordinary aeroplane article will recognize its justice.

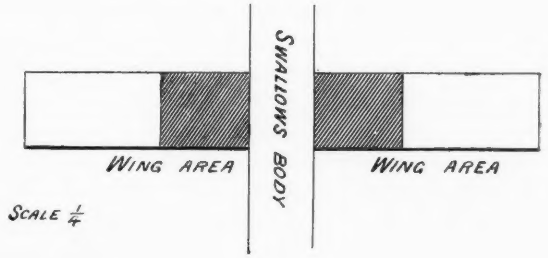
[1] Harting's formula $\frac{\sqrt{\text{wing-surface in sq. cm.}}}{\sqrt[3]{\text{weight in grammes.}}}$, which governs this ratio in birds, is impugned by R. von Lendenfeld in the volume that we have been quoting from (Ann. Rep. Smith. Inst. 1904, p. 129). The figures of his example in proof will not, however, bear examination. Correctly calculated they strongly support Harting $\left(\frac{\sqrt[2]{336}}{\sqrt[3]{320}} = 2{\cdot}68\right.$, and *not* 4·03 as given by Von Lendenfeld as the ratio of the partridge$\left.\right)$.

[2] Some notes by Prof. Moseley ("Notes by a Naturalist on the 'Challenger,'" p. 571, 1874) upon the small amount of true soaring performed even by the albatross are instructive. Our eyesight misleads us again in this matter.

Take a quite typical example of the common aeroplane blindfold acceptance from writer to writer of palpable impossibilities as guiding facts. In the article that we have been quoting from we may note the following (p. 500): "The best estimate has been that an ordinary flight may extend from 30 to 50 yards in less than twenty seconds." In order to get working figures we may call "30 to 50 yards" 40 yards, and "less than twenty seconds" 15 seconds. This gives a rate of $5\frac{1}{2}$ miles an hour!

Note this, you who watch the fish fleeing before a 14-knot steamer.

Such statements are the habit of the problem. Just in the same way is it its recognized habit to quote, unquestioned, as "sailing" parallels to the heavy small-winged fish, the $\frac{3}{4}$-oz. large-winged swallow, and the parachute whose work is falling only; or, again, to faithfully reproduce over and over again pictures of impossible air-currents performing feats also impossible; or to continue to ascribe the frantic efforts at flight of a fish fallen on deck to natural spasms, although it is not credited with active use



of its wings either in air or sea; and so on. It is the way of the problem, and no one is to blame.

Perhaps the odd unsuitability of the swallow comparison may be brought more fully home by a sketch.

The ratio (Harting's formula) of a swallow (house-martin) is 4.2, and its wing-area 120 sq. cm. The flying-fish ratio is 2.6. If we reduce the swallow to a 2.6 ratio, its wing-area becomes about 47 sq. cm.

This reduction to flying-fish ratio is shown by the shaded parts of the sketch.

Could anyone contend that a swallow could sail even in its present poor and much-assisted way (for it is far from being a first-class sailer) if the unshaded parts of the wing-areas were removed?

Opinion is, however, undoubtedly changing. Many of the old shibboleths are fast becoming discredited. The great distances that the fish, under favoring conditions, fly clear of the water [1] — the fact that they fly in calms as in winds — that they come on board ships from lee and weather sides indifferently — that they can and do turn in air [2] — that they often lose and often gain speed, both from simple causes, on meeting a wave or on tail-dipping — that they can and do at times gain speed whilst still in air — that they make for lights deliberately — that they rise and fall of set purpose while in the air: all these and much more that has been under the ban are being witnessed and certified to so incessantly that soon only the high-priests of aeroplane will be left contradicting them.

F. G. Aflalo ('Natural Hist. of Australia,' Macmillan & Co., 1896) writes: "I have watched these beautiful creatures by the hour and in all weathers, ... but after having closely watched thousands of them through strong glasses, I cannot give as emphatic

[1] It is difficult to judge distance at sea. The tendency is to underestimate it. Many observers testify to having seen flights of more than a quarter of a mile. Frank Bullen, in his article upon flying-fish in 'Creatures of the Sea,' insists that he has seen flights of over a mile. He has had exceptional opportunities for observing them, and I see no reason for thinking that he is mistaken.

[2] With reference to their turning powers. I mentioned in the former paper a fish which I had seen to turn back in air. I then restricted myself to the bare facts required for the argument. It had interested me, however, much at the time, not only because it was, to me, a rare occurrence, but also because the controlling cause of the fish's remaining and turning in air was quite evident. The sea was rather calm and the ship was throwing out, with each gentle roll and dip, those broad hissing tables of white foam which spread away for many feet from her sides, and die in a mass of struggling bubbles, to reappear as the white broad rushing table of the next dip. The fish had risen independently of the ship, and was flying towards us at full speed, when a sudden slow down marked its perception of the advancing monster. There was no time, however, for it to decide whether water or air was the less perilous before it was over an unusually broad table of boiling foam. The hidden and fearful possibilities of this evidently decided it, and then ensued its slow but successful struggle to turn and get clear of the concealed horrors. This it did with what must have been a terrific effort, but it got quite round and well away out into the blue water before it dived.

an opinion as I should like on the oft-discussed question of whether the wings vibrate like those of birds.... If the pectoral fins are so constituted as to be capable of vibration, then I would say as the result of my own observations that to some slight extent they do flap, not like those of birds, perhaps, certainly not like those of the bat."

I have quoted the above as it expresses markedly two common difficulties: (1) the real difficulty in discerning the movements; (2) the pre-acquired idea that the wings are not fitted for flapping, an idea which naturally greatly increases difficulty (1). Had Mr. Aflalo been certain of the two facts that the wings were fitted for flapping and that "sailing" was for the fish ordinarily impossible, it cannot be doubted that his views would have been stronger and expressed very differently.

Among quite recent papers upon this question, two should be especially noted. Lionel E. Adams, B. A., writes in the 'Zoologist' (April 4th, 1906) an article interesting throughout. I quote from p. 146: ".... I was often able to see them against the sky.... I could see quite distinctly that their tails were vibrating very rapidly from side to side during the whole flight, and that the wings would vibrate with an intensely rapid shivering motion for a second, then remain outspread motionless for one or two seconds, and then vibrate again. This vibration of the wings is not up and down as in the case when birds fly, but in an almost horizontal direction."

That is a quite possible explanation of the mode of flight, provided that a sufficient speed be acquired in the intermediate flappings, but this the known speed of the fish shows to be not commonly the case.

Again, on p. 148: "I am perfectly well aware that a casual glance at flying-fish from the lofty deck of a liner gives the impression that they soar like birds with motionless wings, but watch them at close quarters from the deck of a low-waisted tramp and the vibratory motion of the tail and fins will be quite plain."

Interesting as is Mr. Adams's paper, I cannot but think that he is partly mistaken in his views, and that the wing-vibration which he discerned was really less rapid than the movement in the period following which he believed to be one of stillness, just as the line-passengers mistook his vibrations for stillness. I do not say that

the fish could never arrive at a speed by which a very short aeroplane flight could be attained even with their low ratio; but I do say that such is not their common speed, and that in any case their disregard of wind-direction disproves such flight.

Therefore another way must be looked for, and we are driven back, perforce, to continuous wing-action, the manner of which may be here examined as carefully as our information allows.

Premising that the flight varies greatly on different days and under different conditions, the following is probably a fair description of their methods in an ordinary flight:—

1. The tail-impelled, visibly (to many) wing-assisted jump from the water to a height where the wings can work freely.

2. The flight continued by an intensely rapid and labored wing-movement — one easily mistaken for stillness, and usually seen, if at all, as blur.

3. Short periods of slowing down of wing-speed, during which the wing-movement becomes again visible. (These are the "vibration" periods, representing to aeroplanists loose wing-trailing, or dragging like a flapping flag—an impossibility; and, to Mr. Adams, periods of wing-assistance — with limitations a possibility.) These periods often precede a special spurt such as is required to lift the fish over an oncoming wave.

4. Either sudden cessation of wing-movement and consequent immediate drop into the sea or a short slow down into visibility (No. 3) previous to such drop.

It is to be noted that this vibration so often seen before the fish enters the water is one of the many pointers to continuous wing-movement, for such a time is a proper one for slowing down, but an absurd one for renewal of wing-effort.

To return to Mr. Adams's paper. He notes, as have others, the vibration of the wings as being in "an almost horizontal direction." This horizontal movement, if it exists, as is probable, may afford, as I hope to show, a looked for key to the fish's action.

According to Pettigrew, it is a necessity of flight, where wing-beats are in a more or less vertical direction, that the up-beat should meet with little and the down-beat with much resistance from the air. This is arranged for in the case of bats, birds, and certain insects by means of special muscles and ligaments which automat-

ically flex the wing for or during the up-stroke, and extend it for or during the down. (Pettigrew, 'Animal Locomotion,' Int. Science Series, vol. vii. pp. 122, 182, 194, &c.: 1891.)

Marey ('Animal Mechanism,' p. 263 &c.: Int. Science Series, 1893) equally recognizes the necessity for a diminished wing-area in the up-stroke, but believes it to be obtained in birds through the natural elasticity of the feathers, which enables them to return to their ordinary position when the resistance of the air in the down-stroke ceases to raise them.

The flying-fish's wing, as is known, is formed on quite a different principle from that of a bird or bat. It opens and closes somewhat like a fan. A partial automatic closing of this fan at the foot of the downward stroke in flight and opening at the top of the rising stroke would both give the appearance of horizontal vibration when seen either from above or below, and would turn a somewhat difficult question of the mechanics of the flight into a very simple one. Indeed we have here flying action on the same general principle as that shown by Pettigrew and Marey to be necessarily provided for in the case of bats and birds, but the working details of which are different and simpler, as becomes a simpler form of wing.

Perhaps that is the explanation. There must, of course, be some explanation, and that is not only the natural deduction from the peculiar formation of the wing, but it also fits everything in.

The known (but indistinct) visibility of the larger rays of the wings at times during flight points, perhaps, to a comparative pause with wings full open before beginning the down-stroke. Such pause would give the open position, and with it the wing-tracery prominence.

The form of these fishes' wings points to this fan-action rather than to other known horizontal wing-actions of the nature of that of certain insects — the common fly, for instance (Marey, *loc. cit.* pp. 204, 206).

The second quite recent and very important observer and writer on this subject is convinced of the flight-action. He writes also from personal observation, and is as free from proper mechanical bias as from the improper follow-my-leader habit. One of his remarks, "It is by no means impossible that flying-fish may soar,

as *even* [my italics] birds do this," shows his mechanical freedom. In a paper dated Oct. 28th, 1905, Brig 'Galilee,' North Pacific Ocean, Dr. J. Hobart Egbert, Carnegie Expedition, writes ('Forest and Stream,' Jan. 27th, 1906): "Though still denied by some observers, the power of propulsion through the air by means of its fin-wings is generally accorded the flying-fish.[1] During months at sea in the tropics the writer has almost daily watched the flying-fishes and studied their flight through the air.... The difficulties of assuring oneself that the flying-fish moves its wings during its flight through the air are well understood, and also the fact that these difficulties are generally removed when opportunity is afforded of observing the flight of certain of the larger species under favorable conditions. That flying-fishes use their wings after the manner of birds, at least upon emerging from the water, can hardly be denied, since from the fo'c's'le head of a ship plying the waters of the lower latitudes this wide bird-like motion of the fin-wings may be easily observed as the large flying-fishes break water almost under the vessel's bow. This flapping motion of the fin-wings is not, however, long maintained, but as soon as the fish is well started in the air apparently passes into a vibratory motion of the appendages so rapid as to be almost beyond human visual perception."

Quite so. That is the to-be-expected flight of an exceptionally low-ratio flyer having special added natural disabilities. Before long it will be the accepted one for flying-fish.

More about the Pectoral Muscles.

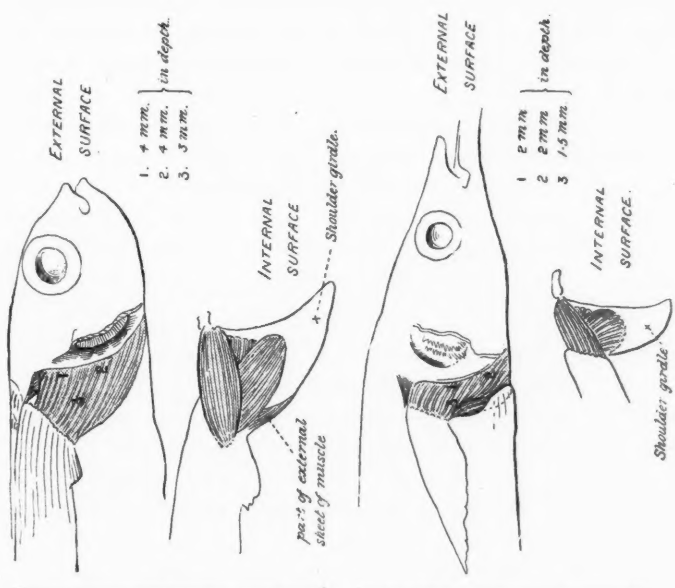
Since writing the foregoing I have received a communication from Prof. C. Stewart, F. R. S., Conservator of the Museum of the Royal College of Surgeons, who kindly gives me permission to use the results of a dissection made at the Museum for the purpose of comparing the pectoral muscles of the flying-fish with those of a nearly related non-flying fish.

I quote from the letter of Mr. Burne, who made the dissection:—

[1] A little premature, if Natural Histories and Encyclopædias are any indication of general accord.— C. D. D.

"Royal College of Surgeons of England,
Lincoln's Inn Fields,
London, W. C., 18th June, 1906.

"Dear Sir,—. . . . I have made a dissection of the pectoral muscles of a flying-fish (*Exocœtus* sp.) and of a nearly related fish of much the same build, but without the enlarged pectoral fins (*Hemiramphus*). Both were specimens from our store-room, and although in pretty good condition had evidently been in spirit for a considerable time. I enclose you tracings of the drawings I



Exocœtus Hemiramphus

made. The two of the external view were drawn with a camera, and the *Hemiramphus*, which was rather less in girth than the *Exocœtus*, was so much enlarged as to have the same girth about an inch behind the pectorals. I thought that body-girth sufficiently far behind the fins not to be influenced by their degree of develop-

ment was the best standard of size to take — better than length, for instance. As a matter of fact, the fish were very much the same length; the *Exocœtus* being rather the longer.

"The drawings, I think, explain themselves. The flying-fish muscles were, as you see, considerably larger, both in area and in thickness, than in *Hemiramphus*, and the same was the case with the muscles on the deep surface of the fin. In their arrangement they were much the same in both fish and the same as in other bony fishes (the cod, for instance). The numbers on the surface of the fins are the points where I took the thickness of the muscles by plunging a needle into it and measuring the depth to which the needle entered. You will notice the great length of the muscles in *Exocœtus*: a long muscle means a proportionate length of contraction.

" . . . . there is a very marked difference in the size of the muscles of these two fishes. . . .

"Believe me, yours faithfully,

R. H. BURNE
(*Assistant in Museum*).

The above tracing seems to give, roughly, about $4\frac{4}{5}$ times greater bulk of muscle to the *Exocœtus* than to the *Hemiramphus*. With this light it will not be out of place to requote and amplify the one "proof," distinguishing the addition by italics: — "The pectoral muscles of birds depressing their wings weigh on an average one sixth the total weight of their body, the pectoral muscles of bats one thirteenth, the muscles of the pectoral fins of flying-fish . . . . one thirty-second," *and the muscles of a nearly related non-flying fish only one hundred and fifty-fourth.*

As before, it does not prove that bats or flying-fish flap or do not flap their wings, but it gives a different and, I hope, a proper aspect to the figures which have done duty — of a kind — for so many years.

CONTRIBUTIONS TO MUSEUM TECHNIQUE

I. CATALOGUING MUSEUM SPECIMENS[1]

L. B. WALTON

An essential feature in connection with a museum, is the maintenance of a careful record or history of the objects forming the various collections, since a specimen deficient in data referring to the locality, date and conditions under which it was obtained, is practically valueless in comparison with one correctly catalogued.[2]

The inadequacy of the systems commonly employed, even in prominent museums of America and Europe,[3] by which rarely more than a number, name, and locality of uncertain value, are more or less heterogeneously arranged in cumbersome and often inaccessible volumes,[4] is apparent to any one who has attempted to locate a desired specimen, or when fortunate enough to ascertain the location, to obtain concise information concerning it. This condition of affairs is particularly obvious to the systematist wishing to study the material belonging to a certain group or from a definite area in a museum, for he may indeed be considered

[1] Contributions from the Biological Laboratory of Kenyon College, No. 5.

[2] I have merely given expression to the principle laid down by Goode in his admirable paper on museum administration (Annual Report of the Museums Association, 1895, also republished in the Annual Report of the Smithsonian Institution, 1897) where he says, "A museum specimen without a history is practically without value and had much better be destroyed than preserved."

[3] The museums as well as many other institutions abroad, are subservient to precedents which, under the changing conditions, have too often outlived their usefulness. The remarks of Dr. Meyer in a note on a succeeding page (unintentionally on his part) furnish excellent evidence in corroboration of the above statement.

[4] Both the Field Museum of Chicago and the Carnegie Museum of Pittsburg make use to a limited extent of card or slip catalogues in connection with the book system. From their form and size ($3\frac{1}{2} \times 9\frac{1}{4}$ in the former, $5\frac{1}{4} \times 8$ inches in the latter museum) method of filing, and arrangement of data however, it is questionable whether a decided advance has been made over the old book catalogue.

a fortunate individual if, after the loss of much time examining the collections on exhibition and in storage, both catalogued and uncatalogued, and in consulting the various volumes in which the data are supposed to be kept, he obtains the data which he wishes.[1]

Consequently the following suggestions in respect to the cataloguing (often spoken of as 'registering' or 'recording") of specimens have been brought together primarily with a view toward facilitating the maintenance of such records in museums of Natural History, although it is hoped that they may prove of practical advantage in connection with other institutions of a similar nature. The paper was outlined and partially written while engaged in the rearrangement of certain collections in the American Museum of Natural History, New York, during the summer of 1901. The completion, however, although a brief review was published in the Ohio Naturalist for 1904, has been delayed in order to make further inquiries concerning the systems of cataloguing used in various museums, as well as for the purpose of profiting by a more extended practical application of the method. This latter result has been accomplished in the cataloguing of specimens during the last three years for a foundation of a small museum at Kenyon College. It may be noted that very few changes from the plan first proposed have been rendered necessary.

The literature relating to the subject of cataloguing museum specimens is chiefly conspicuous by its absence, notwithstanding the mass of information in regard to museums and museum administration which has been brought together in the Museum Journal and a few other periodicals devoted to the interests of such institutions, and in the papers by Meyer :00–03, Gratacap :02–03,

[1] In a vigorous article by Bather (How may Museums best retard the Advance of Science, Annual Report of the Museums Association, p. 90–105, 1896) some of the difficulties of locating museum specimens are described as follows. "Many years ago I journeyed to Strassburg on purpose to examine certain specimens that had been described by Mr. de Loriol. The various curators whom I met at the Museum assisted me very willingly throughout three days searching for these specimens, but they could not be found, and I went on my way sorrowing. Arrived at Freiburg, I mentioned the fact to my friend, Professor Steinmann, who suggested that possibly the specimens might have been overlooked as being in the Cartier collection. At considerable expense and inconvenience I therefore returned to Strassburg, and sure enough, there were the specimens carefully obscured."

Murray :04, etc. Meyer (p. 419) briefly outlines the method used in the Field Columbian Museum, while Murray (v. l. p. 264) somewhat naïvely suggests that "As a rule it is of importance that the exact locality from which each specimen has been obtained should be recorded....This does not apply to archaeological objects alone....The date of finding or acquisition is often likewise of importance."

There are nevertheless a few papers which should be mentioned. Hoyle, '91, described the cataloguing of specimens in the Manchester Museum and formulated a system of 'registration' in book form, and of 'cataloguing' through the use of cards. His registration catalogue corresponded to that designated in the succeeding pages as The Department Catalogue. It consisted of fourteen volumes bearing reference letters A–O, beginning with A–Mammals, B–Aves, etc., and ending with N–Mineralogy, and O–Anthropology. Each volume contained space for 12500 specimens and was ruled in perpendicular columns so that space for data concerning 'date,' 'name,' 'locality,' and 'remarks,' was afforded. When a specimen arrived at the museum, the first vacant number in the volume corresponding to the group to which the specimen belonged, was affixed to it and the data concerning it noted in the appropriate column. After the specimen was thus 'registered' (*i. e.*, our Department Catalogue) it was farther catalogued in what Hoyle described as the "Curators Catalogue" (*i. e.*, our Reference Catalogue) by means of which an official record of the contents of the museum arranged according to a natural classification, was maintained. This is very similar to that which I have termed The Reference Catalogue. It consisted of a buff 'family-card' $5 \times 3\frac{1}{8}$ inches, on which the name of the family (*e. g.* CIDARIDAE) was written, a gray 'genus card' containing the generic name (*e. g.* Cidaris), and a white 'species card' having the specific name (*e. g.* hystrix) and the mode of preservation, the register number (*i. e.* department number), and locality.

The method of registration presents, in comparison with a card system, the usual disadvantages of the book catalogue as noted on a succeeding page. The absence of a practical means of cross indexing the various volumes by tabs and colored cards

representing systematic divisions, geographical distribution, type specimens, etc., is at once manifest. Furthermore no space is given for noting the authority for identification, date collected, etc., name of collector, etc., for all of which data provision should be made.

The "Curators Catalogue" may be criticized on this same basis. Moreover in a catalogue, the chief purpose of which is that of a reference or finding catalogue, there seems every reason for arranging the cards in alphabetical order in preference to classifying on a systematic basis. Hoyle, himself, in noting some objections to the decimal system proposed by Petrie in *Nature*, mentions the fact that "no specialist is ever satisfied with any other specialist's work." Furthermore unless arranged according to the alphabet as suggested under the Reference Catalogue, it would be of no value to the public. The cards adopted should naturally be of a standard size since odd sizes cannot be perfectly cut by reason of the expensive machinery used. Ordinary 'guide cards' would be much better than the 'genus' and 'family cards.'

Dorsey, '99, reviewed the method of cataloguing used in the Field Columbian Museum of Chicago. As suggested in a preceding footnote, this appears to be more or less of an heterogeneous arrangement of cards, books, and manilla envelopes, which could be much simplified.

Walton, :04, published a brief outline of the present paper noting the division into (a) The Accession Catalogue, (b) The Department Catalogue, and (c) The Reference Catalogue, as well as suggesting the general scope and methods of filing the cards employed in each.

Wray, :05, called attention to the adoption of the card system in the Perak Museum of the Federated Malay States, a result brought about by the unsatisfactory nature of the book method of cataloguing. A single type of card (3×5 inch) was used. This contained the following data: 'Accession No.,' 'Date when received,' 'Place in Museum,' 'Description of Specimen,' 'Where procured,' 'How obtained,' 'Presented by,' 'Bequeathed by,' 'Purchased from,' and 'Collected by.' Duplicate cards were made out, one set being filed numerically as a 'Register,' the other according to the arrangement of the specimens in the museum

(each museum case being given a number, and each gallery a letter, e. g. 17 F) as a 'Catalogue.' The 'Register' evidently corresponds to that which I have designated the 'Department Catalogue,' lacking the method of cross indexing by departments, marginal tabs, and colored cards (when desirable). The 3×5 inch cards used by Wray are too small, while the writing of two sets for each specimen nearly doubles the clerical work involved in the use of an Accession, Department, and Reference catalogue as noted in the following pages, since by the latter method a large number of specimens are usually transcribed on a single department and reference card. Space for certain valuable data is likewise omitted by Wray, something unavoidable however with the small card.

From the first it seemed evident that the card catalogue arranged in unit cabinet sections would furnish the most satisfactory solution of the problem. The value of such a system had long ago been recognized in connection with library and general business methods, where it rapidly displaced the bulky volumes formerly considered necessary to contain various records. The advantages resulting from the use of the card system are obvious, since (1) the required data are presented in a compact and easily accessible form; (2) the capacity is unlimited, useless records can be taken out or new ones added; (3) by varying the position of the tab [1] on the upper margin of the card, as well as by using cards of different colors, a variety of cross reference systems may be employed; furthermore, (4) the form of the card allows the condensation of matter which would extend across one or more pages in a catalogue.

The standard sizes of cards[2] manufactured in America, are 3×5, 4×6, and 5×8, inches, and although other sizes could be made and used, it is well to adopt one of these, inasmuch as the regular card cabinet section can thus be employed as a unit and the special machinery used is particularly adapted for the three sizes. The 3×5 inch cards are too small, and for general purposes the 5×8

[1] The word 'tab' is the term applied to the projecting portion of the upper margin of the card.

[2] The 'standard size' (No. 33), adopted by the American Library Association in 1878 for library use, is 125×75 mm. ($2\frac{61}{64} \times 4\frac{59}{64}$ in.).

inch cards are too large and unwieldy. The 4 × 6 inch card, however, is of sufficient size to contain all necessary data, without being cumbersome in manipulation.

Card cabinets to contain the catalogues may be obtained in various sizes, but by the adoption of the 'unit' card index section containing six drawers adopted for the 4 × 6 in. card, future units may be added as occasion demands, and the cabinet is thus always complete.

Following a chronological order, the data which should be rendered accessible in an adequately catalogued collection, can be separated into three divisions. These are: (A) The Accession Catalogue, containing a general record of all material received by the museum. (B) The Department Catalogue, giving a complete history of each specimen or group of specimens, (a single species, acquired by each department. (C) The Reference Catalogue, having the names of all specimens belonging to each department, arranged alphabetically so that the final disposition of any desired specimen can at once be ascertained.

Of these, the Accession and Department catalogues are essential from a business as well as a scientific standpoint, while the Reference catalogue, although not a necessary requisite, will be found advantageous as a reference index to the specimens, particularly in the larger museums. With the exception of the one pertaining to accessions, which should be in charge of the director of the museum, each catalogue should be controlled by the head of the particular department with which it deals.

While the records considered necessary vary more or less in connection with the needs of the institution and department concerned, they can in general be reduced to the following tabular form, covering the data which may be required in Museums of Natural History.

A. Accession Catalogue (arranged numerically).
  1. Accession number.
  2. Date received.
  3. Description.
  4. How obtained.
    a. Purchase (cost).
    b. Gift.
    c. Exchange.

    d. In trust.
    e. Museum collectors.
  5. From whom received.
  6. Address.
  7. Transportation number.
  8. Collector.
  9. Locality where collected.
  10. Date when collected (approximate).
  11. Correspondence filed under.
  12. Remarks.
  13. Date of entry.

B. Department Catalogue (arranged numerically)
  1. Department number.
  2. Accession number.
  3. Original number.
  4. Number of specimens.
  5. Sex.
  6. Stage of growth.
  7. Scientific name.
  8. Authority for identification.
  9. Date of identification.
  10. Locality where collected.
  11. Name of collector.
  12. Correspondence.
  13. Date when collected.
  14. Character of specimens.
  15. Remarks.
  16. Date of entry.

C. Reference Catalogue (arranged alphabetically)
  1. Name of specimen (common name and scientific name,— genus, species,— listed on separate cards).
  2. Department number.
  3. Character of specimen.
  4. Location.
    a. On exhibition. Case No.
    b. In storage. Drawer No.
  5. Number of specimens.

The following suggestions have been found valuable in regard to the data and their arrangement on the cards.

A. ACCESSION CATALOGUE.

In this catalogue, all material[1] received or collected at a particular time from a particular source, (an accession), is placed under a single accession number. Thus the catalogue will contain a record of each group of specimens coming into the possession of the different departments in the museums, and by means of a series of cross references, consisting of tabs arranged as indicated

Fig. 1.—Cards (4 × 6 in.) from *Accession Catalogue.* The position of the marginal tabs suggest the various 'departments' into which it is convenient to subdivide a small museum. The arrangement of data is here uniform for each department. A numerical guide card and year card are represented. The commercial (blue) ruling for guide lines is not reproduced.

in the accompanying illustration (Fig. 1), it will be possible to ascertain at any period the data concerning the accessions acquired

[1] While it is equally the same whether one specimen or one million specimens are received, the terms 'particular time' and 'particular place' are necessarily subject to considerable latitude in their interpretation. If certain systems of cross references are used it may be necessary to place a collection under several different accession numbers. For example, if cards of various colors represent geographical distribution (*e. g.* Nearctic, etc.), it would be necessary to use as many accession cards as there were regions represented in the particular collection.

by each department, whether they have been obtained by purchase, gift, exchange, through museum collectors, or in trust, and if by purchase, their cost, as well as the particular fund made use of in connection with their acquisition.

The disposition of each item on the card should correspond to its relative importance. In the following diagram (Fig. 1) a convenient arrangement is suggested.

Classification by Departments.— A classification by departments can be conveniently maintained by having tabs arranged on the cards in as many different positions as there are departments. Thus with ¾ inch tabs as in Fig. 1, eight departments may be tabulated.

Accession number.— This should occupy a prominent place, preferably the upper left hand corner, and in order that it may be easily noted, should be written in a large plain figure with black or red ink.[1] The numbers should be serially arranged in accordance with the date of arrival of the accession, and at intervals of one hundred cards, a numbered guide card of a particular color (*e. g.* dark blue) may be inserted. Where no previous catalogue of this nature has been kept, it may be well to have new accessions commence with a number sufficiently large (*e. g.* 1001) to allow the eventual cataloguing of former collections which have come into the possession of the museum [2] in a manner as nearly chronological as possible.

Date received.— The most convenient formula for expressing the date on which an accession is received, is the use of an Arabic numeral for the day of the month and a Roman numeral for the month, followed by the year (*e. g.*, 6–IX–1898 = September 6, 1898). The usual place for the date is the upper right hand margin. At the end of every year, a card can be inserted, on the tab of which the particular year is indicated (Fig. 1). Thus the mate-

[1] It is perhaps unnecessary to remark that in records of this nature india ink should always be employed and cards of the best quality be used. Inks made of aniline colors will fade within a few years.

[2] When accession catalogues have been maintained separately by the departments, the numbers in the new catalogue must be of a higher order than the sum of the previous ones used, provided it is desired to maintain the approximate chronological order.

rial obtained by the museum during any particular period is at all times readily ascertained.

Description of material.— The general nature of the consignment should be indicated, (*e. g.* archeological material, mammal skeletons, fishes) as well as the manner in which it is packed (number of packages, boxes, etc.). In this connection a record should also be kept as to whether the accession is received as a 'purchase,' 'exchange,' 'gift,' 'in trust,' or through 'museum collectors.' This can be readily accomplished by having the above words written on the card and placing a cross in the proper space at the time of cataloguing. When procured by purchase, the price should also be indicated.

From whom received.— The name and permanent address of the person sending the specimens, is to be noted here.

Transportation number.— It is often convenient to have a record of the number or numbers placed upon the consignment by the transportation companies, particularly in the event of breakage or loss of any of the contents of a package or box.

Name of collector.— Many collections are deficient in labels bearing accurate information, consequently it is advisable to ascertain the names of individuals concerned in collecting the specimens, so that if desirable, further data may be obtained. The address of the collector is to be noted, provided it differs from that of the locality where the collection was made.

General locality.— When the collection is a small one from a restricted locality, this can be readily indicated. If, however, a large amount of material is represented, the principal region or regions should be given.

Date when collected.— It is necessary to indicate merely the approximate time.

Correspondence.— In order to readily refer to correspondence, invoices, bills, and other memoranda relating to the accession, it is well to indicate the initial name or number, together with the year, under which they are filed.[1]

Remarks.— Under this heading can be noted the condition of

[1] Madeley :04 presents an elaborate arrangement for the classification of office papers in Museums based upon a provisional decimal system. It seems unfortunate that the standard decimal system (Dewey) was not utilized.

the specimens whether or not the collection contains any forms of particular value (types, cotypes, etc.), as well as other general information.

General suggestions.— In order to record small collections, which may come directly to a department, blank cards may be provided for those in charge, and upon the arrival of such an accession, these should be immediately filled out and handed to the person keeping the Accession Catalogue. Blank cards to be similarly filled out and returned, can be sent to a person from whom an accession deficient in data is received. The system of cross references can be arranged to meet any demand. The method employed as noted above, appears adequate for ordinary purposes. Thus the name of each department is placed on a tab assigned to a particular position, and when the cards are filed, the accessions of a department will be indicated by the corresponding row of tabs. A further subdivision which may be applied to each department is in the use of colored cards. If for example the department of anthropology, possesses three separate appropriations upon which to draw for as many purposes, *e. g.*: (a) Explorations on the North Pacific Coast. (b) The purchase of Michigan Antiquities, and (c) Collections illustrating the life of the Aztecs; all accessions in Anthropology of (*a*) obtained by purchase, or at the expense of the museum from the one fund, can be placed on salmon colored cards, while similarly all accessions of (*b*) and (*c*) obtained from the corresponding appropriations can be placed on buff and blue cards, respectively. Thus at any time the general condition of the various funds of the department can be readily ascertained. Geographical Distribution (*e. g.* nearctic, neotropical, etc. may be represented in a similar manner.

Placing numerical guide cards at intervals of every hundred cards, will greatly facilitate finding any desired accession number. In a catalogue where the width of the tabs makes it possible to have an area at the right from which no tabs project, it is convenient to place the numerical tab as in Fig. 1.

Inasmuch as the majority of accessions cover a quantity of specimens, such a catalogue as the one described can be easily maintained, and the advantages which result through always having correctly classified data accessible are an important item in the making up of reports.

B. DEPARTMENT CATALOGUE.

The department catalogue has the cards arranged numerically in chronological order and should contain concise information concerning each specimen, or group of specimens belonging to the same species which were obtained at a definite time and place. In the smaller museums the material may be grouped under departments of Zoology, Botany, Palæontology, etc. as represented by

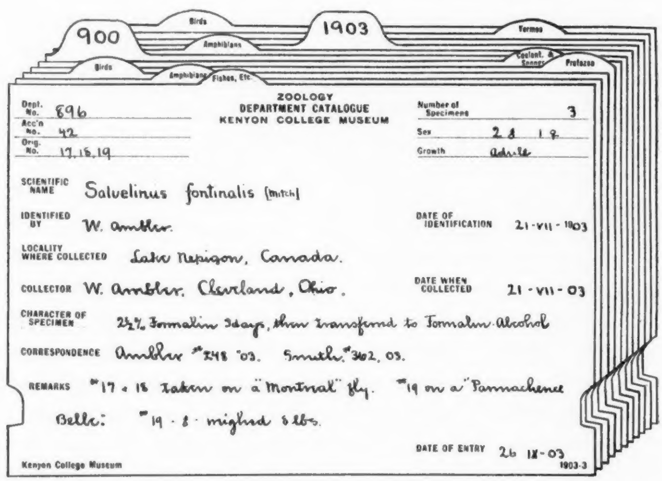


FIG. 2. *Department Catalogue*, Zoology, cards (4×6 in.), showing arrangement of data, and method of systematic cross indexing by position of small marginal tabs (*e. g.* Fishes, Amphibians, Birds, etc.). The color of the card furnishes a second system of cross reference illustrating the geographical distribution (*e. g.* white=Knox Co. Ohio; salmon=Ohio exclusive of Knox Co.; buff=all territory outside of Ohio. Numerical and year guide cards are also shown.

the Accession Catalogue (Fig. 1) each with its separate department catalogue. In the larger museums, however, it will often be advisable for each department to have several sub-departments or group catalogues having the rank of departments. For example the department of Zoology may maintain catalogues of Vertebrate and Invertebrate Zoology, or of Pathological preparations, Neurological specimens, etc., or on a systematic basis it may have a catalogue for each phylum or branch of the animal and plant kingdoms. The cross-reference classification by means

of tabs, however, as represented in the department catalogue (Fig. 2) will usually be sufficient in the smaller museums.

Here the arrangement of data will meet the needs of the average department. Near the middle of the upper margin of the card should be placed the name of the particular department to which it refers, together with the name of the institution. If the department is large so that group catalogues are necessary, this should also appear, *e. g.* Zoology Department Catalogue, South African Museum, Birds.

Systematic cross reference classification by tabs. — The classification adopted will depend on the nature of the catalogue. If half-inch tabs are used on a 6 inch card twelve divisions are possible which in the zoological department cards above consist of 1. Mammals, 2. Birds, 3. Reptiles, 4. Amphibians, 5. Fishes, etc. 6. Tunicates, 7. Echinoderms, 8. Articulates, 9. Mollusca, 10. Vermes, 11. Coelenterates and Sponges, and 12. Protozoa. For certain reasons an arrangement in the reverse order would be more logical. In a botanical catalogue one could choose between the older classification of Eichler, 1883, where a somewhat arbitrary grouping gives us the 1. Algae, etc., 2. Lichens, 3. Bryophytes, 5. Ferns, 6. Gymnosperms, and 7. Angiosperms, and the recent one of Engler,[1] 1904, with thirteen groups and 35–40 classes. The classification adopted in the other department catalogues, Palæontology, Anthropology, etc., will in a similar manner represent to a more or less extent the personal equation of the curator under whose supervision they are maintained.

Geographical cross reference classification by colors.— Geographical distribution may easily be indicated by having cards of a particular color represent definite areas. Such an arrangement does not appear to render the card system so complex that it is disadvantageous, although over-systematizing is a danger which confronts any general method.

If the collection is local in its character, the majority of specimens being obtained from a given state, an excellent arrangement is that of having all specimens from the county in which the collection is located, catalogued on white cards; all specimens from

[1] Engler, A. 1904. Syllabus der Pflanzenfamilien, 4th edition, Berlin.

the state excluding the county, catalogued on buff colored cards while other specimens from localities outside of the state would be catalogued on salmon [1] colored cards. In the larger museums where collections are made up of specimens from different parts of the world, certain colors can be used to represent various regions, (nearctic, neotropical, palæarctic, etc.). Types, cotypes, etc. could be catalogued on cards having the right half red, the left half in accordance with the color representing the particular geographical distribution.

Department number. — A single department number will cover a series of specimens of the same species, which have been obtained at the same time in a particular locality. This method is more satisfactory than assigning a number to each individual specimen inasmuch as time would be lost by such a method and no particular benefits result. Should the occasion arise at a later period, a separate number may be assigned to any specimen.

Accession number.— This should be indicated on the card, in order that general information regarding the collection may be obtained at any time. The accession number and department number may be indicated in connection with the specimens as a fraction (*e. g.* $\frac{294}{896}$) whose numerator represents the accession number, and denominator the department number, or as a decimal (294.896), or the accession number may be entirely omitted from the specimens, since a reference to the department card will furnish it when desired.

Original number.— This is the number which a specimen may possess on its arrival. Often times it will be the field number placed on it at the time when it was collected or it may refer to a number assigned in a previous collection.

Number of Specimens.— This is essential in order to know the amount of material in any collection. When duplicates are used for exchange, the former number should be crossed out and the new one substituted, while, at the same time, a reference number referring to the exchange may be added.

Sex.— The sex can be designated by the conventional signs, ♂, ♀, ☿, representing, male, female, and hermaphrodite forms.

[1] These colors are suggested inasmuch as the majority of manufacturers of cards in the United States make them in four standard colors, white, buff, salmon, and blue.

Growth.— Embryo, young, adult. Measurements, weight, etc.

Scientific name.— In systematic work of this nature the generic followed by the specific name must be used.

Authority for identification.— This is an important item which is too often omitted from the average museum catalogue. If a specialist subsequently verifies a name previously given, this should also be noted. In case the name is found incorrect a new card is to be written.

Date of identification.— It is well to have this information available.

Locality where collected.— Too much care cannot be exercised in accurately indicating the locality from which specimens are obtained. It is safe to say that every museum has among its collections material which would be of the utmost value, provide the locality, even within a few hundred miles, could alone be ascertained. Unfortunately in most cases of this kind, it is the collector who is at fault. The cataloguer must rely on his data.

Name of collector.— Inasmuch as the 'personal equation' must be taken into consideration, the name of the collector is indispensable. Furthermore it often furnishes a clue to the history of a specimen when all other means have failed.

Correspondence.— Letters, etc., pertaining to the particular specimens can be indicated as suggested in the accession catalogue.

Date when collected.— This can be indicated as in the accession catalogue.

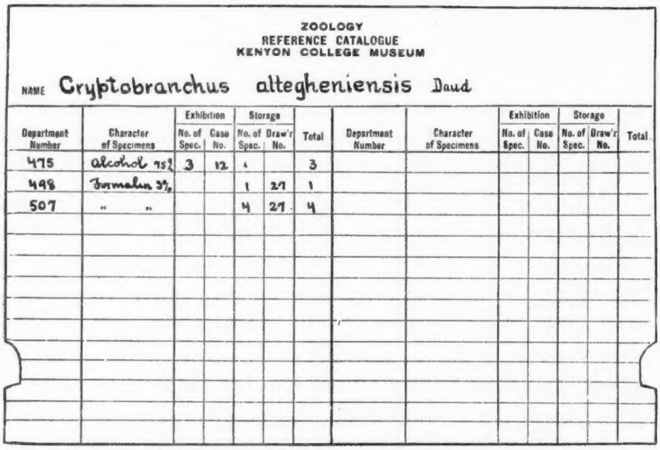
Character of specimen.— The nature of a specimen, whether a skeleton, an anatomical preparation, a mounted skin, etc., should be given. If preserved in a special manner it is well to indicate the formula, *e. g.* 5% formalin; 70% alcohol; killed and hardened in chromosmic 3 hours, preserved in 95% alcohol, etc. Explicit notes here will in the end well repay the time spent in making them. The back of the card will afford additional space, if needed.

Remarks.— This space is only to be filled out when there is something of particular importance to be noted concerning the specimen, and of a nature which cannot be covered under the other records.

General suggestions.— The data, as well as their arrangement on the cards, are naturally subject to various changes, in order to conform to the requirements in different museums. It is well to have a blank space for each item of information concerning the specimen, although often unnecessary, or even inadvisable, provided there is reason to doubt its accuracy, to fill it out. As in the Accession Catalogue numerical guides should be placed at intervals of one hundred cards, while 'side locking cards' are recommended.

C. REFERENCE CATALOGUE.

The Reference Catalogue may with equal propriety be termed a finding list, since its purpose is that of indicating the location of


ZOOLOGY
REFERENCE CATALOGUE
KENYON COLLEGE MUSEUM

NAME Cryptobranchus allegheniensis Daud

Department Number	Character of Specimens	Exhibition No. of Spec.	Exhibition Case No.	Storage No. of Spec.	Storage Draw'r No.	Total	Department Number	Character of Specimens	Exhibition No. of Spec.	Exhibition Case No.	Storage No. of Spec.	Storage Draw'r No.	Total
475	alcohol 75%	3	12			3							
498	Formalin 3%			1	27	1							
507	" "			4	27	4							

FIG 3.—Reference Catalogue card (4×5 in.). One card will usually contain data referring to 50–100 specimens. The cards to be arranged alphabetically, the scientific and 'common' names to be on separate cards. An alcove or hall letter may be added to the case number. The permanent position of the card in the drawer may be assured by use of a central rod.

each specimen which belongs to the particular department in the museum. The cards are arranged in alphabetical order, both the scientific name (generic followed by specific name in the case of biological specimens), and the common name having a place on separate cards, the latter, however, referring to the former,

(*e. g.* opossum, see Didelphys. Furthermore, the reference card indicates the number of specimens of each species on exhibition, or in storage, giving the number of the case or storage drawer in which they are to be found.

A single card will usually contain the data concerning all material belonging to a particular species, consequently the time involved in maintaining a Reference Catalogue is an unimportant item, the data (except location of specimens) being readily obtainable at any time from the Department Catalogue.

The Reference Catalogue should be located in the principal room containing the collections to which it refers, where it will be readily accessible to each of the three classes of people for which a museum primarily exists: (a) the specialist, (b) the amateur, and (c) the general public.[1]

One method for arranging the data for a reference catalogue, is shown below (Fig. 3).

Systematic Cross Reference Classification by means of Tabs.— An excellent method which meets the usual requirements, is that of having the tabs arranged as in the Department Catalogue. Geographical cross reference by colors cannot be used inasmuch as one card will often contain specimens from widely separated localities.

Name of specimens.— Both the scientific name and the common name should be given, the former on the card containing the data, the latter on a separate card referring to the generic or specific name of the particular species. (*e. g.* Brook Trout, see *Salvelinus fontinalis*, Pickerel, see *Esox*, various species). By placing the common name on cards having a particular color they may be readily distinguished.

Department numbers.— Inasmuch as the department numbers will be placed on all material, this will serve to establish the identity of the specimen sought, and in case further data is required, the corresponding number in the Department Catalogue can be consulted.

Character of Specimens.— In alcohol, mounted, skeleton, skin, etc.

[1] See Bather, F. 1904. The Functions of a Museum; a Re-Survey. Pop. Sci. Mo., v. 64, p. 210–218.

Exhibition, Storage, etc.— The location of a specimen is indicated by the particular column under which it is placed. If on exhibition, the number or letter of the case [1] will be given. Alcoves or galleries may be designated by letters. If on storage, the location will be similarly designated.[2]

Total number of specimens.— These columns will indicate the total number of specimens of a given species [3] belonging to the museum. If customary for the institution to make many exchanges a balance column may be added, which will show the material on hand as well as that exchanged.

The necessary steps incident to the cataloguing of a collection which has been received may now be outlined as follows.

a. Catalogued as an Accession.

b. Placed in charge of a department.

c. Catalogued in a Department Catalogue and given a department number.

d. Identified and labelled. This data then added to the department card.

e. Placed on exhibition or in storage.

f. Reference Catalogue filled out from data on department card.

The first three items should be attended to at once. A considerable interval will often elapse however before final desposition of the specimen is made.

It would seem that only two general objections can be urged against any system similar to the one proposed, namely; (1) The plea that too much time will be occupied in the preparation of such a catalogue, and (2) a certain inherent condition which precludes the adoption of new ideas. The only answer that need be given

[1] If the case is a large one and contains a quantity of specimens, it may be convenient to indicate the number of the shelf, etc.

[2] The practice of having separate department catalogues for the exhibition and storage series, is to be criticised. Different species thus possess identical numbers, and when it becomes necessary to transfer a specimen which has outlived its usefulness for exhibition purposes, to the storage collection, complications at once ensue.

[3] When it becomes desirable to include a collection in a guide book to the museum or to issue a general catalogue of the specimens, the question involved is merely that of selecting the data here classified.

to the former is that the space occupied by a specimen unworthy of being properly recorded, is more valuable than the specimen itself, while to the latter no reply is needed.

It is unnecessary and often inadvisable to at once reduce former catalogues to a card system. Incoming material can be catalogued on the cards, and as the opportunity allows, data from the previous records can be transferred to cards.

Conservatism [1] is a valuable factor in connection with all scientific work. It has its limitations however, and in order to make definite progress in any direction, old methods must give place to new ones — the fittest will survive.

KENYON COLLEGE, GAMBIER, OHIO. Dec. 1, 1906

[1] Meyer, (:00–01) in his excellent review of the museums of the eastern United States depreciates the lack of uniformity among the various American museums in respect to the installation of the collections. In reply to this criticism however it might well be suggested that to a certain extent at least this lack of uniformity is an indication of healthy activity. It is not considered necessary in this country to cling to traditional ideas which are too often brought to the attention of one visiting European museums. New methods of dealing with well known problems are sought and evolved — and if their value is proven — they are adopted.

Since the above paragraph was first written (Aug. 1901) Dr. Jordan in his presidential address before the members of Sigma Xi (Dec. 31, 1903) expressed similar ideas regarding this tendency which he had noted. "In France, in Germany, even in England, the tradition of great names, the customs of great museums, largely outweigh the testimony of the things themselves.— The willingness to adopt new ideas is, broadly speaking, in proportion to the spirit of democracy by which a worker is surrounded."

BIBLIOGRAPHY

Dorsey, G. A.

'99. (The Cataloguing of Museum Specimens), American Anthropologist, n. s., 1, p. 473.

Meyer, A. B.

:00–01. Ueber Museen des Ostens der vereinigten Staaten von Amerika. R. Friedlander und Sohn, Berlin. (Also see translation in Report of the U. S. National Museum for 1903, p. 311–808 with 40 plates).

Hoyle, W. E.

'91. The Registration and Cataloguing of Museum Specimens. Annual Report of The Museums Association, Cambridge, England.

Madeley, Chas.

:04. The Classification of Office Papers. Mus. Jour., v. 4, no. 3, p. 73–95.

Murray, David.

:04. Museums, Their History and their Use. 3 vols., J. MacLehose and Sons, Glasgow, Scotland.

Walton, L. B.

:04. The Cataloguing of Museum Collections. Ohio Naturalist, v. 4, no. 3, p. 62.

Wray, L.

:05. A System for the Registration of the Contents of Museums. Museums Journal, June, p. 407–412.

SOME SOUTH AMERICAN ROTIFERS

JAMES MURRAY

The undernoted rotifers were obtained from moss kindly sent to me by Mr. N. D. F. Pearce, of Cambridge, England, in the early summer of 1906. The moss was sent from British Guiana. The locality from which it came was unknown, but it was somewhere in the interior.

A portion of the moss was still moist, but most of it had been dried. The majority of the species were got from the dried moss.

As is usual when dried moss is examined after a lapse of some time, most of the rotifers found belonged to the order Bdelloida. Of this order 13 species were distinguished; 11 of the species were already known, most of them being common and widely distributed species. One, *Callidina perforata*,[1] was only recently discovered in India, and a very distinct variety occurred more abundantly than the type. *C. multispinosa* was represented by a variety, probably of specific value. Two new species are here described.

Four species of the order Ploïma were also found,— one Colurus, two Monostyla,— and one Diglena. I was unable to determine any of these.

Order Bdelloida

Callidina angusticollis Murray (:05).— Very abundant. All the examples belonged to the type, or to a small variety. The Indian variety *attenuata* did not occur.

C. perforata Murray.— The most abundant species in the collection. The type (Fig. 1) was fairly plentiful, but a variety, described below, was much more so.

C. p. var. **americana** var. nov. (Figs. 2–3).— Case smaller than in the type, length 106 μ (type about 136 μ). Posterior process

[1]Murray, James, "Some Rotifera of the Sikkim Himalaya." *Journ. Roy. Micr. Soc.*, 1906.

sharply marked off by abrupt constriction, not turned to dorsal side as in the type, but in line with the axis of the case; — perforation towards ventral side (dorsal in type). Dorsal plicæ of the case not distinct, but an obscure tesselation or coarse stippling instead. As in Indian examples, empty cases usually lacked the ventral wall, as though some enemy had found this part vulnerable.

C. constricta Duj. ('41).— Plentiful.

C. aspera Bryce ('92).— A few examples.

C. habita Bryce ('94).— One example, living.

C. quadricornifera Milne ('85–'86).— One small hyaline example.

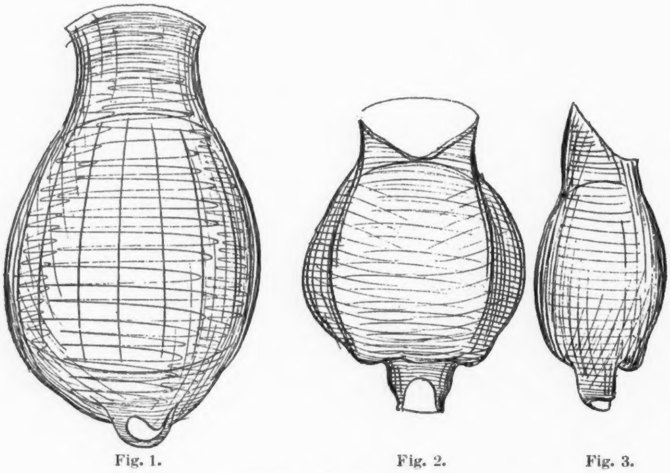


Fig. 1. Fig. 2. Fig. 3.

Callidina perforata Murray.

C. multispinosa Thompson ('92).— In Britain I have found this species variable only within narrow limits. In various warm countries I find many forms related to this species, sufficiently distinct and apparently constant, which are probably distinct species. They are so numerous that I think it would be well to make further comparisons of them before deciding how many of these forms are good species, and I make all provisionally subordinate to *C. multispinosa*. In British Guiana the type was not found, but two varieties were frequent. One variety has all the spines very short. It has a superficial resemblance to *C. papillosa*,

but the arrangement of the spines shows that it belongs to this species. This variety is also found in India and Africa.

C. m. var. **crassispinosa** var. nov. (Fig. 4).—Long anterior spines few, usually 4 on each side, the 2d and 4th of these much thicker than the others. The lateral spine of the anterior row on the central segments of the trunk large and very thick. Skin strongly stippled or papillose.

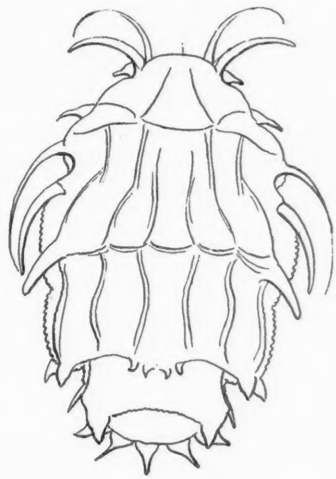


Fig. 4.
Callidina multispinosa, var. *crassispinosa*.

Other smaller differences from the type will be better understood from the figure. There was no variation from this arrangement of spines in all the examples seen. The variety is much smaller than the type. About 6 examples seen.

C. ehrenbergi Janson ('93).— One living example.

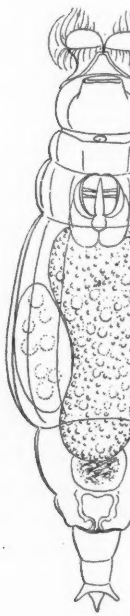
C. tripus n. sp. (Figs. 5–7)

Specific characters.— Small, 240 μ long, hyaline or whitish, with pale yellow stomach, food not moulded into pellets. Head small, corona 40 μ wide, less than collar and about half diameter of central trunk, discs touching, central process of upper lip single, truncate. Length of antenna $\frac{1}{3}$ diameter of neck. Jaws 18 μ long, teeth 2/2, very thin. Foot 4-jointed, spurs narrow, tapering, divergent; toes large and long, the two ventral put out and drawn in, in the usual manner, when making the step, the dorsal kept always extended and forming with the spurs a tripod. Dorsal skin folds faint, few, lateral deeper. The striking peculiarity is the tripod, which is unique in the order. Otherwise the animal comes nearest *C. ehrenbergi* Janson, from which it is distinguished by the smaller head, closer discs, and truncate upper lip. Abundant.

C. speciosa n. sp. (Figs. 8–10)

Specific characters.— Very small, 163 μ feeding to 238 μ creeping. Head very small, diameter of corona 26 μ, of prominent collar 38 μ. Food not moulded into pellets. Teeth 2/2. Anal segment with lateral prominences. Foot 3-jointed, first joint with lateral processes, spurs small, tapering, divergent. Toes three. Dorsal longitudinal and ventral transverse skinfolds forming symmetrical pattern, which is constant. Length of antenna half diameter of neck.

The most distinctive character is the pattern formed by the



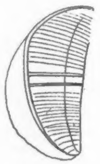
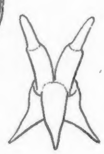


Fig. 6.



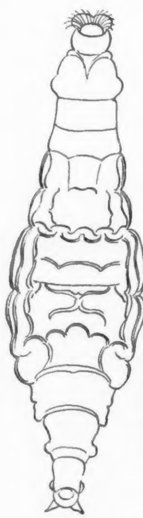


Fig. 10

Fig. 5. Fig.7.
Callidina tripus n. sp.

Fig. 8. Fig. 9.
Callidina speciosa n. sp.

skinfolds. Many species have a similar pattern formed by the dorsal wrinkles, but no other species has the ventral surface so ornate. Apart from this character it has no close resemblance

to any other species. Those which approach it in general form and dorsal wrinkling have larger heads with separated discs.

Not abundant, about a dozen examples seen.

Rotifer longirostris (Janson) ('93).—Several examples of the type were found, but none of the Indian varieties occurred.

Adineta gracilis Janson ('93).— Not plentiful.

A. vaga Davis ('73).— Rare.

LITERATURE

Bryce, D.
'92. On the Macrotrachelous Callidinæ. *Journ. Quekett Micr.* Club, ser. 2, vol. 5, p. 15.

Bryce, D.
'94. Further Notes on Macrotrachelous Callidinæ. *Journ. Quekett Micr. Club*, ser. 2, vol. 5, p. 436.

Davis, H.
'73. A New Callidina. *Month. Micr. Journ.*, p. 201.

Dujardin, F.
'41. Zoophytes Infusoires, p. 658. Paris.

Janson, O.
'93. Rotatorien-Familie der Philodinæen, Marburg.

Milne, W.
'85–'86. Defectiveness of the Eye-spot, etc. *Proc. Phil. Soc. Glasgow*, vol. 17, p. 134.

Murray, J.
:05. A New Family, etc. *Trans. Roy. Soc. Edinb.*, vol. 41, p. 367.

Thompson, P. G.
'92. Moss-haunting Rotifers. *Science Gossip*, p. 56.

MERISTIC HOMOLOGIES IN VERTEBRATES

J. S. KINGSLEY

One of the most difficult problems in vertebrate morphology is to explain the serial homologies between the different groups. In the lower segmented animals these difficulties, although they exist, are far more simple and are far more easily explained. Thus no one has any doubt that the tenth or the fifteenth somite of Homarus is the exact equivalent of the serially homologous somite of Cancer. Between the larger Arthropodan divisions the task of comparisons of somites is possibly not so easy yet all attempts at drawing homologies between, say, a hexapod, an arachnid and a crustacean, are based upon the assumption of exact serial equivalency. It is true that one author or another has at times suggested the possibility of intercalation or elision of a somite, but these have been mere suggestions and have usually been discarded in the discussions.

In the vertebrates this comparison is more complicated. We are forced to assume that the shoulder girdle and fore limb of the frog are the homologues of those of man, although their connections are with entirely different somites when serial position is taken into account. In the case of the pelvic arch the numerical disparity of the corresponding somites is even greater, but in either case the identity of structure of arch and limb is so great that doubt of homology is practically impossible. How then has it come about that say the twelfth somite of the Amphibian is not homologue of the twelfth but of more nearly the twentieth of man?

In Gegenbaur's hypothesis that the girdles are derived from branchial arches and that these have migrated backwards over the post-cranial somites we have a possible explanation of these problems of the relations of girdles to body segments. The backward migration has been arrested at different points in the various

groups. But this explanation will not suffice for other cases, hence the probability that it is true for none.

In the frog as in all Ichthyopsida, there are but ten cranial nerves, while in the mammals there are twelve. There is no doubt that as far back as the tenth the nerves are exactly homologous in Amphibia and in the mammals. Relations to brain and to points of distribution place this beyond question, but what shall be said of the mammalian eleventh and twelfth? Are both of these nerves from the post-cranial region which have been transferred to the skull? If so, does it not follow that the cranium in the higher vertebrates is not the exact equivalent of that in the lower? and that the differences have been brought about by the transformation of cervical into occipital vertebræ. If this, in turn, be so, are the occipital bones of the frog homologous with those of the mammal? Or are the basi-, ex- and supra-occipitals of the one merely analogous of those of the other? Is Huxley's argument for the derivation of the mammals from the Amphibia because of the double occipital condyles in the two groups based upon analogies rather than on true homologies? Are the condyles in Amphibia and Mammals not homologous but rather homoplastic formations?

Carrying this matter further back in the body, how are we to explain that apparent shifting of the pelvis in such a form as Necturus as described by Bumpus, Parker and others? Are somites ten, twenty and the like exactly equivalent in the normal and aberrant forms? And has there been an actual shifting of the pelvic girdle from one somite to the next in some individual? Or has there been an actual intercalation of vertebræ, the one to which the ilium is attached being constantly the same morphologically if not serially? Or, lastly, have the limbs and their arches arisen from a continuous fin fold and has every somite which contributes to that fold the potentiality of limb formation with all that this implies?

To take another case. In Amphioxus there are a large number of gill slits, a number which is doubled during development by the formation of the 'tongue bar.' Right behind the last gill slit comes the entrance of the hepatic duct into the alimentary tract, there thus being no œsophagus nor stomach intervening between

the pharynx and the liver. Is this to be explained by saying that in the vertebrates the posterior gill clefts of Amphioxus have closed and that the space which they occupy has become converted into stomach and œsophagus? In other words are these formations of the vertebrate tube the homologues of a part of the gill region of the acraniate?

Then, too, what are to be done with cases of increased numbers of gill slits; the Notidanids with six or seven, the Californian Bdellostoma with its variable number, and Amphioxus itself? This question is wholly apart from that which discusses the relations between metamerism and branchiomerism.

Numerous other similar questions will readily suggest themselves to all. There is no reason for enumerating them here. The problem is, how are they to be explained. Must we find a separate explanation for each or can we find some one principle which will account for all?

This article is to be regarded in the light of a suggestion rather than a full reply with demonstrations of validity. I have no proof, other than analogies and the fact that the hypothesis here presented answers all the demands of the problem, that the explanation here advanced is the true one. It must be tested and the tests are not easily made.

In the invertebrate segmented animals there is, at the beginning, no metamerism. It appears later during growth, and in numbers of forms it is found that the segmenting tissues are produced by budding from groups of cells at the posterior end of the embryo. These are most familiar in the annelid teloblast and are scarcely less well known in the Insects and Crustacea. Their number varies between wide limits, but for the present purposes the most important points concerning them, aside from their budding capacities, are their position in a more or less plainly marked transverse band and their situation at the extreme posterior limit of the growing embryo. Extensive examination of the literature has not shown similar budding cells in the Cuvierian group of Articulata in other places than the tip of the growing embryo, with the exceptions noted below.

It follows then that in these teloblasts and their equivalents are the full potentialities of the future somites. From them arise

all the cells which are utilized in every structure which is metamerically repeated, the material for the new somite not being budded from any pre-existing somite, but always just in front of the hinder end of the body.

This applies strictly to all cases which are known to me in the arthropods as well as to most of the annelids; but in a few of the latter group modifications occur in the process which have great interest for us. As is well known in a number of annelids asexual reproduction by transverse division occurs. At one or more points in the body a new head may develop with the eyes, appendages, etc., characteristic of the anterior end of the worm, these features arising from a somite which in its earlier stages is apparently normal and like its fellows on either side. Then, just in front of this new head the worm divides and two worms, each with fewer somites than the original one, are produced and from this time onward lead an independent existence.

Of these only the anterior worm need now be considered. After the separation the segment which was just in front of the new head of course becomes the terminal somite of the new worm. The worm now increases in length and the new somites are formed by material cut off from the terminal somite which thus must have within it the equivalent of the teloblasts of the embryo.

From these facts it seems logically to follow that at least certain somites in the body have the potentialities of forming material for additional somites and must contain within them the same physiological possibilities as the original teloblasts from which they arise. In other words, in the annelid before the beginning of the transverse division the capacity for producing new tissues was located at more than one point in the body, but it was not exercised until after the asexual reproduction was well advanced.

In the case of the Naides the somites thus produced are all similar in character but in such instances as Protula, where heteronomous somites occur, the division of the worm is accompanied by the formation of new somites which differ in kind.

The application of these facts to the various types of meristic variation which occur in annelids need not be discussed here, but I think it is apparent that they will in part explain some of them. I do not mean to say that they reveal first causes but they do point

out the mechanism involved and may be used to reduce all to a common rule.

In the same way the assumption that there are similar budding zones at various points in the vertebrate body will explain the various conditions outlined in the statement of the problem. In the vertebrates there is a continuous addition of new somites at the posterior end of the body as in the arthropods and annelids, implying the existence of the equivalents of teloblasts at the posterior end. The assumption of budding zones at other points will explain the other features noted. Such a zone in the occipital region will allow us to explain the difference in the number of cranial nerves in the mammals and in the Ichthyopsida and yet allow us to accept the homology of the occipital bones throughout the vertebrate series. The additional nerves are thus to be regarded not as transferred from the neck but as new or intercalated structures. In the same way we may explain the varying number of vertebræ in the different regions and allow at least one of the pelvic vertebræ to be regarded as a fixed point and may be relieved of any assumption of a shifting of the girdles. It will also explain many anomalies such as the attachment of the two halves of the pelvis to different vertebræ and the increased number of lumbar or thoracic vertebræ in man.

This is to be regarded solely as an hypothesis. So far as I am aware no one has seen such budding zones in any vertebrate. In fact it is extremely probable that there is no such well defined zone as is found in the band of teloblasts of the crustacean. It is to be regarded rather as a series of assumptions, based in part upon analogies, which, if true, would explain the questions with which the present note began. The hypothesis is presented as a suggestion to stimulate investigation and criticism upon an interesting and difficult subject.

ON THE OSTEOLOGY OF THE TUBINARES.

R. W. SHUFELDT.

I. Historical.

Few of the groups of Birds have a more interesting literature than this Suborder.

As early as 1827 M. L'Herminier placed the Tubinares together in a family of birds (28th) and classified them upon the characters of their sterna, assigning them to three sections; (1) the smaller Petrels in which the xiphoidal end of the sternum was entire or nearly so; (2) the Albatrosses, where it presented a shallow notch upon either side of the carina; (3) those Petrels in which two well-marked notches occurred on either side of the sternal keel.[1]

M. M. Hombron and Jacquinot in the year 1844, added something to our knowledge of the Tubinares,[2] and they classified the group upon the morphology of their palates, tongues, and beaks. In one genus they placed the three genera Diomedea, Puffinus and Priofinus, in another, the genus Prion, and finally, in their third genus,— Procellaria. By them Pelecanoides was removed from the Procellaridæ, and placed in the Alcæ near Alle, which they considered its nearest relative (*A. nigricans*). Five years later Gray and Mitchell (1849) divide the Procellaridæ into the Diomedeinæ and the Procellariinæ, and the last named into 5 genera (Prion, Pelecanoides, Thalassidroma, Procellaria, and Puffinus), the group constituting the fourth family of their Anseres.[3] In his Conspectus, Bonaparte divides the Procellaridæ into the Diomedeinæ, Procellariinæ, and the Halodrominæ; the second

[1] Recherches sur l'appareil sternal des Oiseaux, pp. 79–81. v. iv. Paris, 1827.

[2] Remarques sur quelques points de l'anatomie et de la physiologie des Procellarides, et essai d'une nouvelle classification des ces oiseaux, *Compt. Rend. de l'Acad. Sci.* xviii, 1844, pp. 353–358.

[3] The Genera of Birds, iii, pp. 646–650.

subfamily being subdivided into five lesser groups.[1] But a few years later (1864–66) this constitution was followed by the far more accurate work of Coues, though that distinguished ornithologist complains of "having suffered not a little from imprudence in believing Bonaparte," whom to some extent he followed, but upon the whole has given us a more natural classification of the Tubinares.[2]

Both Bonaparte and Coues based their classification upon the topographical anatomy of the birds of the suborder we are now considering, but this was not the case with Eyton nor with Milne-Edwards; nor with Huxley who followed them.[3] All these distinguished authors dealt more or less thoroughly with the osteology of many of the Tubinares, as well as with such characters as procellarine species presented externally. Eyton figured the bones of the skeleton of several varieties of Albatrosses, and forms related to them. Milne-Edwards pointed out the relations existing among Petrels, Gulls, and the Steganopodes; showing that the first two were more or less closely akin, and both more remotely related to the last-named group of Birds. Huxley in one of his groups of Schizognathous forms, the Cecomorphæ, in his celebrated paper, placed the Divers, the Auks, the Gulls, and the Petrels in a group by themselves, and of the Procellaridæ says that they "are aberrant forms, inclining towards the Cormorants and Pelicans among the Desmognathæ" (*loc. cit.*, p. 458).

Next of importance we find Professor Reinhardt in 1873, touching upon certain anatomical characters of Petrels, Albatrosses, and Puffins, and presenting his classification of the Group, and to his paper the reader is referred, inasmuch as his results are

[1] Conspectus generum avium, 1857, tom ii, pp. 184–206.

[2] Coues, E. Critical Review of the Family Procellariidæ. *Proc. Acad. Nat. Sci. Phila.* pt. 1, (pp. 72–91); pt. 2, (pp. 116–144); pt. 3, (pp. 25–33); pts. 4 and 5 (pp. 134–197). Parts 1 and 2 appeared in 1864, and the remaining parts in 1866.

[3] Eyton, T. C. Osteologia Avium, Lond. 1867, pp. 221–225.

Milne-Edwards, M. Al. Recherches anatomiques et paleontologiques pour servir a l'histoire des oiseaux fossils de la France. Paris, 1867–68.

Huxley, Thos. H. On the Classification of Birds, etc. P. Z. S. 1867, pp. 415–472.

too extensive to present in this connection.[1] That same year likewise saw Garrod's studies of the Petrels appear, and finding them 'holorhinal,' he parted them from the 'schizorhinal' Gulls and related forms exhibiting a similar character.[2]

Other papers and works of minor taxonomic importance continued to be put forth, when in 1882 appeared the very extensive and meritorious work of Forbes dealing with the entire anatomy of many forms of the Tubinares, and a thorough study of their probable affinities.[3]

Forbes divided the Tubinares into two families, the Oceanitidæ and the Procellariidæ, which last was subdivided into the two subfamilies — Diomedeinæ and the Procellariinæ. Osteology of the Petrels and their allies filled a prominent place in this able production, and I shall frequently have occasion in the present brief article to refer to it, especially in instances where its author had skeletons of species which the writer has not been able to secure.

Another classification is seen in that of Dr. Stejneger which was published in the Standard Natural History (Boston) in 1885. The following selected from his scheme will show where he places the Tubinares: —

Subclass IV.	Super-Order III.	Order VI.	Superfam. V.
Eurhipiduræ	{ Euornithes	{ Cecomorphæ	{ Procellaroideæ.

In the Procellaroideæ are arrayed the three families Diomedidæ, Procellariidæ, and the Pelecanoididæ. This writer places in his scheme the Tubinares widely removed from the Steganopodes, which I believe to be a mistake, and a non-appreciation of the morphological characters of the latter group of Birds.

In his great work upon the anatomy and taxonomy of birds, Fürbringer makes the Procellariiformes an 'Intermediate Suborder'

[1] Reinhardt, J. Om Vingens anatomiske Bygning hos Stormfugle-Familien. Viden. Medd. Naturh. For. Kjöbenhaon, 1873, pp. 123–138.

[2] Garrod, A. H. Collected Papers, p. 128.

[3] Forbes, W. A. Report on the Anatomy of the Petrels (*Tubinares*) Collected during the Voyage of H. M. S. Challenger. (Zool. Chall. Exp. vol. iv, pt. xi, pp. 1–64. Pls. i–vii (1882).)

["This contribution will be found a most valuable addition to the literature on this remarkable order of pelagic birds." John Murray.]

between his Orders Pelargonithes and Charadriornithes. He considers the Procellariiformes to contain the Procellariæ or Tubinares to which group he gives the name of 'Gens.' The Gens Procellariæ according to him contains but the single family — Procellariidæ. Above the Procellariiformes in the Order Pelargornithes we find the Gens Steganopodes.

In 1890 Mr. H. Seebohm in his "Classification of Birds,"— the "alternative scheme" makes an Order of the Tubinares, placing them in his subclass Ciconiiformes, between the Steganopodes and Impennes. Thus his *third* subclass of birds is arranged as follows: —

Subclass.	Order.	Suborder.
3. Ciconiiformes.	Psittaci.	14. Psittaci.
	Raptores.	15. Striges.
		16. Accipitres.
		17. Serpentarii.
	Pelecano-Herodiones	18. Plataleæ.
		19. Herodiones.
		20. Steganopodes.
	Tubinares.	21. Tubinares.
	Impennes.	22. Impennes.

Professor Hans Gadow regards the Tubinares much in the same light as they are by Fürbringer, placing them as an Order Procellariiformes, (9), between the orders Sphenisciformes (8) and Ardeiformes (10), the first suborder of the latter being the Steganopodes.[1]

The 'Procellariiformes' constitute Order XV of Dr. Sharpe's classification, and it is subdivided into a suborder — Tubinares, which latter is made to contain the three Families: (1) Diomedeidæ, (2) Procellariidæ, and (3) Pelecanoidæ. Of this author's scheme, Order XIV contains the Sphenisciformes, and Order XVI, the Alciformes.[2] This authority likewise widely separates the Tubinares and the Steganopodes, the last being included in his Order XXIII or the Pelecaniformes (*loc. cit.* p. 76). In

[1] On the Classification of Birds, P. Z. S. 1892, pp. 229–256. [An able and useful paper.]

[2] Sharpe, R. Bowdler. A Review of the Recent Attempts to Classify Birds. Budapest 1891, pp. 71, 72.

1899 Dr. Sharpe changed this arrangement entirely as will be seen by the following scheme which represents I believe his latest opinions upon this subject.[1] He now places the Procellariiformes between the Sphenisciformes and the Alciformes.

Order (XII).	Family.	Subfamily.	Genera.	No. of Species.
Procellariiformes.	I Procellariidæ.	I Procellariinæ.	Procellaria.	2
			Halocyptena.	1
			Oceanodroma.	13
		II Oceanitinæ.	Oceanites.	2
			Garrodia.	1
			Pelagodroma.	1
			Pealea.	1
			Fregetta.	4
	II Puffinidæ.	I Puffininæ.	Puffinus.	24
			Priofinus.	1
			Thalassœca.	1
			Priocella.	1
			Majaqueres.	2
			Œstrelata.	31
			Pagodroma.	1
			Bulweria.	2
		II Fulmarinæ.	Ossifraga.	1
			Fulmarus.	4
			Daption.	1
			Halobæna.	1
			Prion.	4
	III Pelecanoididæ.		Pelecanoides.	3
	IV Diomedeidæ.		Diomedea.	10
			Thalassogeron.	6
			Phœbetria.	1

This scheme does not enumerate the fossil or subfossil forms given by Dr. Sharpe in the *Hand-List*, of which not a few have been discovered and described. There are about 120 species of Tubinares known to science, and this scheme is very useful in exhibiting at a glance their distribution into genera.

[1] Hand-List of Birds. Vol. I, pp. 120–129. Lond. 1899.

Cope essentially agrees with Stejneger as given above, with the exception that the Superfamilies of the latter are equal to the families of the former. Thus Cope makes the Cecomorphæ contain the families Colymbidæ, Heliornithidæ, Alcidæ, Laridæ, and Procellariidæ.[1]

The writer of the present memoir added his own studies to the literature of this subject in a paper published in 1889, which appeared in the Proceedings of the United States National Museum, it being, in its aim, more descriptive of material then in the collections of that institution, rather than an attempt to classify the Tubinares. In that paper the skeleton of *Oceanodroma furcata* is fully described and figured, also the skeletons of *Fulmarus glacialis* and *F. rodgersii*, ten figures being devoted to the bones of the latter species.

A section is also devoted to the "Osteological points wherein *Oceanodroma furcata* and *Fulmarus rodgersii* differ," and this is followed by some notes on the osteology of *Puffinus tenuirostris* and other material. Finally, a very complete account is given of the skeleton of *Diomedea albatrus*, it being illustrated by twelve figures (nat. size), giving the skull (four views), the vomer (two views), the mandible (two figures), the hyoid arches, the sternum (two figures), and the shoulder-girdle.[2] Taken in connection with my examinations of additional material since that paper was published, and a study of the foregoing works of other authors, the present brief memoir aims simply to bring this subject up to date. I have never been able to get the skeletons of a great many species of procellarine birds, a number of which have been described by Forbes in his above cited work, and the student may readily consult these in the volume of his collected scientific Memoirs published by the Zoological Society of London (R. H. Porter). Either wholly or in part, Forbes examined skeletons of *Diomedea albatrus*, *Thalassogeron culminatus*, *Phœbetria fuliginosa*, *Ossifraga gigantea*, *Fulmarus glacialis*, *F. glacialoides*, *Dap-*

[1] Cope, E. D. Synopsis of the Families of the Vertebrata. The Amer. Nat. XXIII, Phil. Oct. 1889, p. 849 *et seq.*

[2] Shufeldt, R. W. Observations upon the Osteology of the Orders Tubinares and Steganopodes. Proc. U. S. Nat. Mus., Vol. XI, Washington, 1889, pp. 253–315.

tion capensis, Oceanodroma leucorhoa, Oceanites oceanicus, and *Pelagodroma marina.* The skeletons of a number of these have also been examined by me, and in addition thereto I have studied complete skeletons of *Puffinus borealis, P. major, P. griseus* (?), *P. creatopus, Oceanodroma furcata* and others. We also both examined a skeleton of *Puffinus obscurus,* and he also a skeleton of *Bulweria columbina.*

Considering the rarity in collections of the skeletons of tubinarine birds, the ground is pretty well covered by our united examinations, though it is highly desirable that many or all of the others be in time anatomically examined and compared.

II. Some General Notes on the Osteology of the Tubinares.

Bearing in mind what Forbes has recorded in his papers on the *palate* of the Tubinares (*Coll. Sci. Mem.* p. 416), I would say in addition thereto that I find in a skull of *Puffinus borealis* before me, that the inner ends of the maxillo-palatines abut against, on either side, the nearly vertical and lofty scroll of the corresponding palatine. The meeting is quite extensive and coössification appears almost to have taken place at the point of contact. The fenestration in them is hardly evident. We likewise find in the skull of *P. borealis* that the descending plates of the palatines are quite as prominent and well developed as the ascending ones just referred to, while the pterygoidal heads of these bones (palatines) in this shearwater are notably long, and closely applied to each other in the middle line, and to the sphenoidal rostrum. In it, too, the os uncinatum is well seen, being a distinct spine of bone, articulating, upon either side, with the infero-internal border of the lacrymal with its *free* apex pointing downwards and inwards towards the ascending plate of the palatine. In this shearwater the lacrymal is large and pneumatic. It articulates extensively, but does not anchylose with the corresponding frontal and nasal bones, and internally with the broad outer end of the pars plana. Its descending end is bifid and comes in contact with the zygoma, while superiorly its anterior apex is finely pointed, but posteriorly

is blunt and juts backwards and slightly outwards, being found just at the point where the deeply sculptured supra-orbital glandular depression terminates in front. Contrary to Forbes' statement that "well-developed basipterygoid facets are present in all

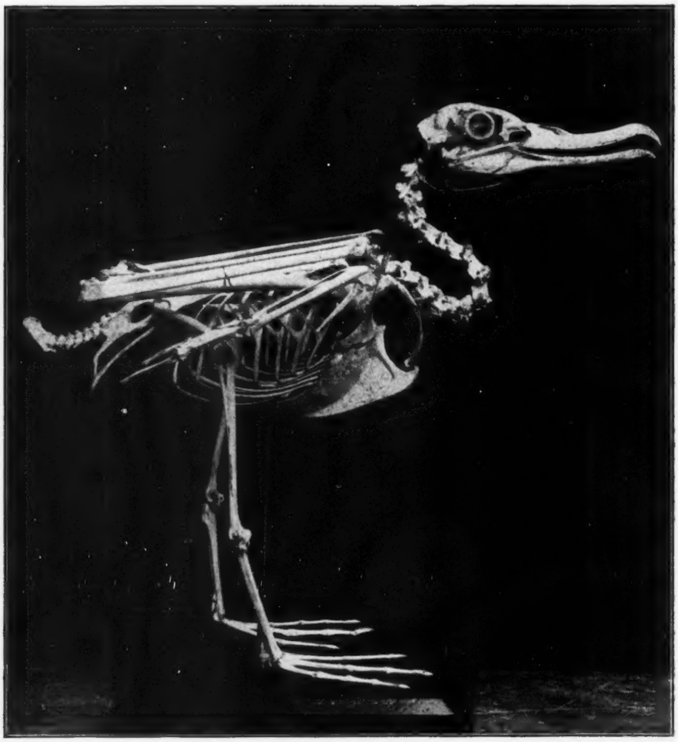


FIG. 1. Right lateral view of the skeleton of a Shearwater (*Puffinus borealis*). Coll. U. S. Nat. Museum, No. 17,772. (From a photograph by Prof. T. W. Smillie, and reduced.)

the forms, except the Diomedinæ, the Oceanitidæ, Procellaria, and Cymochorea," (p. 416), I find them but rudimentary in this specimen of *Puffinus borealis* (No. 17776. Smithsonian Collections), though they are well-developed and functional in a specimen of *Puffinus creatopus* (No. 18,773, Smithn. Coll.). In this last-

named species, too, the maxillo-palatines are well-anterior to the ascending plates of the palatine; moreover, its vomer is notched at its apex, and is not especially curved downward anteriorly. These are three well-marked differences in *Puffinus borealis* and *P. creatopus*, and go to prove, what I have always held, that we can never have too much material before as when comparing the skulls or any other part of the anatomy of birds.

So far as my observation goes I find that Forbes's description of the quadrate bone for the *Tubinares* agrees with what I found in other species of the group not examined or seen by him. But my material does not bear him out so well in his description of the foramen magnum of the Tubinares, and he says that that opening "is more or less reniform, with the major axis transverse, in the small species, whereas in the biggest it is oval, especially in Ossifraga, with the long axis vertical. The moderately sized species are here again intermediate in structure" (p. 417). Of the two shearwaters (Puffinus) before me, birds nearly of a size, and both above the "small-sized species" of the group, it is found to be oval in *Puffinus borealis*, with its major axis vertical, while in *Puffinus creatopus* the foramen magnum is subcircular with the major axis transverse.

The mandible of *Puffinus borealis* has the articular ends somewhat massive, truncated posteriorly, with very deep ramal sides for its hinder half, and very shallow ones anteriorly. Apically it is decurved, and there are lacking recurved angular processes and ramal vacuities. The articular ends are pneumatic, with the facets for the quadrate, of course, the reverse in form to those found on the last-named bone.

The distal elements of the greater cornua of the hyoidean apparatus are much flattened from above downwards, and, as in the Albatrosses, the parts anterior to the basibranchials are not performed in bone. The first basibranchial is subcircular in form, and anchyloses with a short urohyal or second basibranchial (*Puffinus*).

The sclerotic plates in an eye of *P. borealis* are small, and somewhat numerous; they are disposed as we usually find them among birds.

Axial Skeleton: — In the skeleton of *Puffinus borealis* at hand,

I find twenty-one free vertebræ between the skull and sacrum. Of these the thirteenth, fourteenth and fifteenth support a free pair of ribs; they being quite rudimentary upon the first two, but are long and slender on the fifteenth vertebra, and are without unciform appendages. The following *six* vertebræ have ribs that connect with the sternum by costal hæmapophysis. There is also a pair of sacral or pelvic ribs, but their hæmapophyses fail to reach the sternum, and their lower ends make extensive articulation with the last pair of true costal ribs, at some distance above the costal border of the sternum. The pelvis very much resembles the pelvis of Rodger's Fulmar figured by me in the Proceedings of the U. S. National Museum (cited above), and there are eight free caudal vertebræ plus a somewhat elongated pygostyle.

The costal border of the sternum is characteristically wide from side to side, and the pits between the six facettes, unmarked by pneumatic openings, are very shallow. The sternums of these shearwaters agree in their general characters with those of the fulmars.

In *P. borealis* the xiphoidal extremity is doubly notched upon either side of the sternal keel, and the form of the bone is there symmetrical. This is not the case with the xiphoidal extremity of the sternum of my specimen of *Puffinus creatopus*. In it, not only is the left side of the bone somewhat *longer* than the right, but instead of showing the two usual notches of the right, it has three, which appears to have been caused by a bifurcation of the inner xiphoidal process. These inner xiphoidal processes in *P. obscurus* are wonderfully slender.

The shoulder-girdle is much like that of *Daption capensis*, and in Figure 1 I present those parts in that species articulated *in situ* with the sternum. This figure originally illustrated a paper of mine which appeared in the Proceedings of the U. S. National Museum for 1887 (fig. 1, v. X. p. 379), where the skull is likewise described in connection with other observations upon the osteology of the Tubinares, and these should be read in connection with the present memoir.

Returning to the shearwaters, I may say that the arrangement of the bones of the shoulder-girdle in some of them is as we find

it in Daption, and this is the case with *Puffinus obscurus*. The sternum of the former, however, is non-pneumatic, a condition not found in *Puffinus*.

Forbes in his work presents a careful and somewhat lengthy description of the Pectoral arch in general for the *Tubinares*, and it agrees very closely with my own observations upon that bone. I have at present nothing to add to it.

In a specimen of *Puffinus borealis* I find the humerus to measure in length 135 millimetres. The bone is non-pneumatic, and is

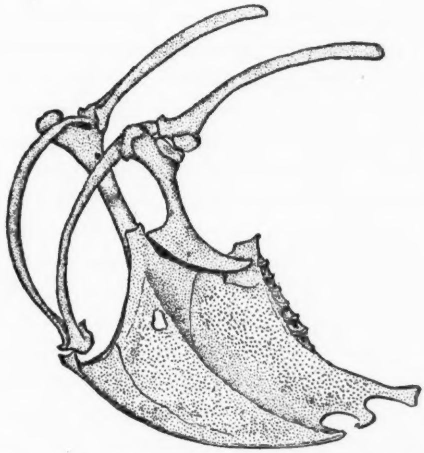


Fig. 1.— Anterior oblique view of the sternum of *Daption capensis*, with the shoulder girdle *in situ*. (Drawn by the author from a specimen in his own collection).

remarkable especially for the prominence of its jutting, papilliform ulnar crest, and conspicuous triangular radial crest. Its shaft is quite straight, and at its distal end, proximal, to the external condyle, we find a strongly developed epicondylar process. Attached to this by ligament is an ossicle of some considerable size, being 14 millimetres long, and of an L-form, with the short arm of the L bent to an obtuse angle. A rather deep, well-defined fossa exists immediately above the oblique tubercle, while the olecranon fossa on the opposite side of the bone is decidedly shallow. "In the Oceanitidæ the humerus is conspicuously a stouter and shorter bone, with its shaft evidently curved instead

of being almost straight [as it is in *Puffinus*]. The epicondylar process projects much less forwards, and is continued down by an elevated ridge to the surface of the condyle itself." (Forbes, p. 422).

Both radius and ulna in Puffinus are comparatively very slender bones, the former, measuring 125 mm., is straight, and presents a well-marked tendinal groove at its disto-superior aspect, over the carpal enlargement. The ulna is likewise a very straight bone in the shearwaters, with the elevations for the quill-butts of the secondary remiges absent from the shaft. Its ends are but very slightly enlarged, as they are in some birds.

The skeleton of the hand has a length almost equaling the length of the radius. The terminal finger-points are long, slender, and pointed distally. Claws are absent. The proximal phalanx of index digit is very long and narrow; its blade not being fenestrated as in the Laridæ. Large and small shafts of the carpo-metacarpus are rather close together and markedly straight. Above its proximal end is a spindle-shaped, free ossicle of some considerable size. Possibly it occurs in the tendon of the tensor patagii longus close to its insertional extremity, but it exhibits no articuiar facette for the wrist, as does the os prominens of the Owls and others.

The small phalanx of the medius digit is notably free, and develops a tendinal tubercle upon its posterior border. Forbes describes the pectoral limb as it exists in the Oceanitidæ, in Adamastor, in Majaqueus, and in Ossifraga of the Procellariinæ, and compares the same as the skeleton of this limb is found in the Diomedeinæ (*loc. cit.* pp. 422, 423).

Puffinus borealis has a femur that in length hardly equals half that of the tibio-tarsus; it is somewhat antero-posteriorly arched, the convexity being along the anterior border. Its upper end is also antero-posteriorly flattened, with the trochanterian crest about absent, and the pit for the ligamentum teres much scooped out. A small free patella exists. In the tibio-tarsus the striking feature is the enormous development of its procnemial crest with a corresponding sub-suppression of the ectocnemial one. This is even still more marked in *Puffinus creatopus*, where upon the posterior aspect of the common prominence, a well-marked, transverse groove exists, apparently for the accommodation of the

lower margin of the patella. The remaining characters of the balance of the pelvic limb of Puffinus have already been correctly described by Forbes, and consequently it will not be necessary to reproduce his description in this place. He has also compared those characters with those found in various other representatives of this group of birds including Diomedea, Pelecanoides, the Oceanitidæ, and the Petrels. (*loc. cit.*, pp. 424, 425.)

In examining the skeleton in the Oceanitidæ I found among other things that they lack in the skull the basipterygoid processes, and that in them the uncinate bones, found in the skulls of other Tubinares are also absent. The posterior margin of the xiphoidal extremity of the sternum, is usually quite entire; and they have but twenty-one cervico-dorsal vertebræ. These birds also possess, in contradistinction to the Procellariidæ, short and stout humeri, a character which is also seen in the long bones of the fore-arm.

III. On the Taxonomy and Affinities of the Tubinares.

There is a combination of a few marked osteological characters which will serve to distinguish any member of the present suborder from any other existing avian group. The Tubinares all have their skulls characterized by the presence of conspicuous supra-orbital glandular depressions, which are large and generally deeply sculpt.

They are likewise all holorhinal, as well as schizognathous birds, wherein the vomer is usually of considerable size, being more or less broad, pointed anteriorly, and often depressed and arched antero-posteriorly. Combined with these characters we find that in them the hallux of pes to be either absent or else rudimentary in that it is reduced to a single joint. Not more than twenty-three cervico-dorsal vertebræ, nor less than twenty-one are seen to exist. The sternum is short and broad, with its posterior border either entire, or regularly 4-notched, or of an asymmetrical pattern, or even jagged. The patella, when present, is free and small, articulating high up on the posterior aspect of the much-produced procnemial crest of the tibio-tarsus. The sternal extremity of a coracoid is of remarkable width, being nearly as wide there as the bone is long from summit to midpoint

of base. The superior mandible of the skull is conspicuously decurved apically, and very sharp-pointed; symphysis of mandible also more or less decurved, and the articular ends of this bone, truncated posteriorly.

When the skeleton of any bird has associated in it all the osteological characters here enumerated, they are sufficient to indicate that the species belongs to the suborder Tubinares. These characters are thoroughly diagnostic, and typical tubinarine forms possess them in the avifauna in any part of the world.

I am of the opinion that the natural classification of the Tubinares is as follows: —

Suborder.	Families.	Subfamilies.
Tubinares.	1. Procellariidæ.	1. Procellariinæ.
		2. Oceanitinæ.
	2. Puffinidæ.	3. Puffininæ.
		4. Fulmarinæ.
	3. Pelecanoididæ.	
	4. Diomedeidæ.	

This arrangement does not include the extinct forms of this suborder, but nevertheless the characters presented on the part of these have been taken into consideration in connection with taxonomical affinities.

When Mr. Forbes came to sum up his conclusions in regard to this group of birds, at the close of his extensive paper, cited above, he said that L'Herminier, A. Milne-Edwards, and Huxley have all, in describing various points in the osteology of the Tubinares, pointed out similarities of various kinds between their osseous structure and that of various forms of Steganopodes, though they still kept them close to the Laridæ. Eyton, on the other hand, places the various petrels he describes in the family 'Pelecanidæ,' and gulls forming a separate family by themselves."

"But no one will be prepared, I think, to dispute that the Steganopodes are allied to the Herodiones, including under that name the Storks and Herons, with Scopus only."

"Thus, on osteological grounds alone, there is sufficient ground for placing the Tubinares in the vicinity of the Steganopodes and Herodines. And, in fact, neglecting the desmognathous structure of the palate — the taxonomic value of which, *per se*, is becoming

more and more dubious as our knowledge of the structure of birds increases — there is little in the character assigned to the groups Pelargomorphæ and Dysporomorphæ by Professor Huxley that is not applicable to the general Petrel type." (*loc. cit.* p. 434.)

In this connection it is interesting to observe that the Tubinares possess, in common with the Cathartidæ, the Steganopodes, and the Ciconiidæ, a deep-keeled, broad and well-developed sternum; external osseous nares holorhinal; articular ends of mandible posteriorly truncated; an evident tendency of the palatine bones to unite with each other for their posterior moieties; powerfully developed clavicles, which are strongly curved, — and these osteological characters co-exist with other similarities to be found in other parts of the morphological organizations of the respective groups mentioned.

Structurally, the Cathartidæ are of great interest, and the anatomy of those peculiar terrestrial scavengers must be still better known to us than it is, before we can hope to trace their probable ancestry.

Remotely akin to the Steganopodes, the Falconidæ, or more generally, the Accipitres, also are linked with these more lowly avian groups,— as are also the Ardeidæ, through Scopus.

During the ages past, it is quite evident that hosts of intermediate forms linking these families and groups have perished and become extinct. This, taken in connection with the very marked specialization of the remaining genera, goes far towards proving the great antiquity of the entire group, and how vast that extinction of the less specialized forms must have been.

My impression is that perhaps the Tubinares on the one hand see their nearest relatives in the Steganopodes, in fact there can now hardly be any doubt upon this point,— while upon the other hand I am inclined to think that the penguins (Impennes) might be with truth placed next below them, as Fürbringer has done. But such questions as these I will take up more thoroughly later on, when I come, in another connection, to draw up my scheme of classification for the Class *Aves,* and after I have paid further attention to the osteology of other existing groups.

NOTE: — In closing this Memoir I would say that since it was written there has appeared in the *American Naturalist* my con-

tribution entitled "An Arrangement of the Families and the Higher Groups of Birds (Vol. XXXVIII, Nos. 455–456 Nov–Dec. 1904, pp. 833–857), and, in so far as the taxonomy of the Tubinares is concerned, it sustains what is set forth above; in other words my opinion in the matter remains the same as it was six years ago.

NOTES AND LITERATURE

GENERAL BIOLOGY

Transmutation and Agriculture.— Much of the evidence upon which the evolution theory rests has been derived from the experiments of practical breeders. It is doubtful, however, whether practical workers have ever greatly profited by the incorporation of the results of their experience into general theories of evolution. The present volume [1] seems to be intended as a general and popular review of the evidence which cultivated plants afford the student of the origin of species, rather than as a guide or handbook for those engaged in plant breeding. Naturally many facts of interest to the breeder are to be found in the discussions of the wide range of material treated, but there is no attempt to formulate rules to be followed in any particular class of practical work or to emphasize the significance of any particular theory of evolution for agriculturists. The arrangement of the material under two main divisions, "Minor Species and Mutation," and "The Factors of Variation," might suggest that the author is inclined to attach much significance to the views of de Vries and to the Lamarckian factors. The source of material is not limited to the results obtained by commercial breeders or agricultural experiment stations, but recent experimental work of all kinds and especially that of de Vries and his followers is quite fully treated. In fact, the volume furnishes a rather interesting index to recent literature bearing on the evolution theory. It must be said, however, that it is not easy to grasp the author's own point of view. The work gives somewhat the impression of a series of reviews, and while it is desirable that evolutionary writings should contain less of theory and more of fact than has frequently been the case, a work loses much in interest if it is not written in support of definite theses which are kept constantly and clearly in view. Wanting, as it does, an obvious central purpose, the book is not one of the kind to found a school and it will probably not influence evolutionary literature materially, but it does furnish a very readable presentation of the results of much recent work and will doubtless be of real service to many to whom the more fundamental works are quite inaccessible.

J. A. Harris

[1] Constantin, J. *Le Transformisme appliqué à l'Agriculture.* Paris, Félix Alcan. 1906. 8vo, 300 pp., 105 figs.

Form Analysis.—Slowly but surely the necessity of applying precise mathematical methods to the solution of many biological problems is becoming apparent to workers in both fields. The chief application of mathematical methods has been in the study of variation and heredity, but the problems of leaf form, arrangement of leaves on the stem, and the convolutions of the shells of gastropods may be mentioned as having attracted the attention of mathematical workers. In an address before the American Philosophical Society, Michelson [1] emphasizes the importance of the problems of symmetry and suggests a classification of symmetrical and unsymmetrical forms.

J. A. HARRIS

GEOLOGY

River terraces at Brattleboro, Vt.— Professor Fisher [2] has tested the theory that the river terraces of New England may be accounted for by the behavior of meandering and swinging streams slowly degrading previously aggraded valleys without necessary change in volume and by the control exerted here and there over the lateral swinging of the streams through the discovery of rock ledges, by applying the theory to the explanation of the terraces of the West River near its junction with the Connecticut. It is found that this theory, elaborated by Davis some years ago, is the only one which will adequately account for the features presented in the district under study.

The lateral swinging of rivers by meanders, cut-offs, and short-cuts is considered, and the evidence in favor of a fourth process presented. This latter, called the 'partition process,' results when a sudden withdrawal of the current from banks of erosion is effected, the stream then forming a sand bar which is not continuous with the former banks, and the sand bar grows to an island which parts the stream. Eventually the deeper channel acquires the entire stream, the deserted channel and former island being thus added to the flood plain. The West River, swinging by these various processes, and at

[1] Michelson, A. A. "Form Analysis." *Proc. Amer. Phil. Soc.*, vol. 45, pp. 110–116, 1906.

[2] Terraces of the West River, Brattleboro, Vermont. By E. F. Fisher. Proc. Bost. Soc. Nat. Hist., Vol. 33, pp. 9–42, pls. 1–11. 1906.

the same time slowly degrading its previously aggraded valley, has encountered numerous rock barriers in its down-cutting, these barriers controlling the extent and character of the lateral swinging, and thus determining the variety of terrace pattern described.

The paper is abundantly illustrated by block diagrams, engravings, and by maps and sections based on a careful survey of the region.

D. W. J.

ANTHROPOLOGY

Quaternary Remains of Man in Central Europe. By Hugues Obermaier.[1] The presence of man in central Europe in the Quaternary no longer admits of doubt. The finds of archeological and skeletal human remains dating back to that period, have been numerous and well authenticated. They have, in fact, become so numerous and publications concerning them are so scattered, that a good grasp of the whole subject is at present a matter of difficulty. Under these circumstances, Obermaier's effort to establish "a list of all the quaternary anthropological discoveries, discarding those the antiquity of which is disputable," is much to be commended. This is especially the case when we learn that the author endeavored to form his opinions by visiting the localities where the finds have been made, by personally examining the collections, and by consulting the men who made the discoveries.

The following succession of stages and substages during which man existed in Europe is admitted:

I. *2nd interglacial stage*

Substages: Chellean (fauna of a hot climate)
Acheulean (fauna of a hot temperate climate)
The Micoque phase (fauna of the steppes)

II. *3rd glacial stage*

Mousterian (fauna of cold climate)

III. *3rd interglacial stage*

Mousterian (fauna of temperate, then of hot climate)
Solutrean (fauna of temperate and finally of cold climate)

[1] Les restes humaines quaternaires dans l'Europe centrale. L'Anthropologie, XVI, 1905, pp. 385–410, XVII, 1906, 55–80.

IV. *4th glacial stage, and retreat of the glaciers*
Magdalenian (fauna of cold climate)
Last quaternary industries

The finds that M. Obermaier considers as indubitably of quaternary age can be conveniently arranged into a table. They are as follows:

Country	Locality	Discovered or first reported by	Nature of the Find	Period from which it dates
Moravia	Cave Špika	Maška	Paleoliths. A fragment of human lower jaw	Mousterian (fauna of cold climate); upper layers more recent
	Předmost	Wankel, Maška, Kříž	Over 25,000 paleoliths. Objects from ivory, bone, wood. Human bones	Corresponding to later Solutrean
	Brno (Brünn)	Makovský	Human skeleton. Objects of stone, bone, ivory	Same as preceding
Croatia	Cave Krapina	Gorjanovič-Kramberger	Human bones. Stone objects	Mousterian (with fauna of hot climate)
Austria	Willendorf	Fischer, Woldrich	Piece of human femur. Numerous implements of stone. Objects of horn and bone	"Paléolithic supérieur" corresponding to that of Předmost
	Cave Gudenushöhle near Krems	Hacker Woldřich	1300 stone implements, objects of horn and bone, a human tooth	Magdalenian
Germany	Taubach near Weimar	Porti, Nehring	Stone implements. Human tooth	Mousterian (hot)
	Andernach near Coblenz	Schaafhausen	Stone implements, objects of bone, wood. Human teeth and parts of bones	Magdalenian (cold)
Switzerland	Cave at Freudental	Karsten	Implements. Human bones	Magdalenian
	Cave of Kesserloch	Merk, Nuesch, Heierli	Numerous stone implements and objects of bone or wood	Solutrean

Among the 'doubtful,' the author places the skulls of most (Brüx), Podbaba, Canstatt, Egisheim, and Neanderthal.

The whole paper is concise, easily read, and furnished with numerous bibliographical references. It is to be hoped the author will follow up the subject and outline in the near future the really ancient and the doubtful human remains in France, and other parts of Europe.

A. Hrdlička

Pagan Races of the Malay Peninsula.[1]—The two handsome volumes of over 1500 pages constitute unquestionably the most important contribution to the knowledge of the less civilized peoples of southeastern Asia. The work, according to the authors (p. VII et seq.) claims to belong to the scope of "descriptive ethnography," but this is rather an unfortunate term because of its redundancy; the text, with the exception of somatological notes, comes wholly under 'ethnology,' as understood in this country. It is "essentially a compilation from many sources, but differs from most books of that kind, first, in being based to a very large extent on materials hitherto unpublished, and accessible only through private channels of information; and secondly, in having been constructed with special knowledge of the subject and in a critical spirit." It is a work of "many facts, but few hypotheses," and should be regarded not solely as a monograph on the tribes dealt with, "but also as a necessary preliminary to a general scientific survey of the races of southern Indo-China and the Malay Peninsula" — which survey is strongly advocated. The objectionable term "pagan," used in the title as a discriminative of races is justified by the opinion that "the point of religion (as between Mohammedan and non-Mohammedan) was perhaps a better dividing line, on account of its definiteness, than the vague, indefinite, and perhaps undefinable, quality of wildness." The bulk of the book was written by Skeat, the attention of Blagden being confined to language.

The contents of the two volumes, besides preface, bibliography, and introduction, are, vol. I: Racial characters and affinities; Notes on diseases; food, stimulants, narcotics; dress; habitations; hunting, trapping, and fishing, barter; weapons and implements; cultivation; arts and crafts; decorative art; social order; dealings with other races; and place and personal names. Vol. II: Birth-customs and beliefs; maturity customs and beliefs; marriage customs and beliefs; burial customs and beliefs; music, songs, and feasts; natural religion and folk-lore; and language. Both volumes are provided with abundant illustrations, nearly all of which are photographs.

The reading of the book reveals a mass of details such as has been brought together in few other works, and which will be of great utility in further studies of the peoples of the Malay Peninsula, as well as that from the mainland further north and the islands to the southward.

Three distinct racial types are recognized, namely the Semang, or

[1] Skeat, W. W., and Chas. O. Blagden. Pagan Races of the Malay Peninsula. 2 vols., 8vo, London (Macmillan & Co.), 1906. 42/net.

Negrito, the Sakai, of suggested Dravidian ancestry, and the Jakun, or aboriginal Malay. They differ principally in head form, physiognomy, and nature of the hair. The Semang are meso- to brachycephalic, with woolly hair, and features approaching, in a number of particulars, the negro; the Sakai are dolichocephalic, with wavy hair and finer features; the Jakun are brachycephalic, with straight hair and with the features of the Malay in general. All are short in stature, but the Semang are the smallest. In color the Semang are chocolate-brown to black, the Sakai and Jakun ranging from brown to yellowish. Both the Sakai and Jakun show numerous instances of admixture with the Negrito.

The chapters on the foods and mode of life of the individual tribes are valuable; but the diseases of the people, their environment, and especially their physiology are far from being treated adequately. The total number of the 'pagan' aboriginies of the Malay Peninsula appears to be no more than 35,000 or 40,000.

For the mass of details concerning the habits, religion, folk-lore and language of the tribes the reader must be referred to the original.

The book as a whole will not be found easy reading. This is partly due to its plan, including several appendices, partly to the many native names, and in some degree to the style of the authors. More tabulation would have been of help. However, the work must be regarded not as a narrative, but more as a reference hand-book of the tribes of the Malay Peninsula, and as such it will be highly appreciated by every student of that region. For this purpose, however, a more copious index, and page references instead of the occasional "will be found in another part of the work," would have been desirable.

The illustrations are not always satisfactory. There are a number of photographs that show but little, and a few (*e. g.* the "Kedah-Raman," "Kedah," superior plane of the Semang skull, the "Semang of Grit," the "Sakai at G. Kerbu," the "Group of Ulu Jelai Sakai") which are wholly useless, being out of focus. It is not easy to see what was the object of the authors or publishers in including these pictures with the many others which are of real value.

A. Hrdlička

Growth of Parisian Children.[1]—The paper presents the results of the determinations of height and weight of 4400 children from various

[1] Tables de croissance des enfants Parisiens de I a 16 ans. Par MM. Variot et Chaumet. Bull. & Mém. Soc. d'Anthrop. Paris, Vme Sér., VII, No. 2, pp. 51–65.

Parisian nurseries and schools. The series includes at least 100 subjects of each sex for every year of life, which insures the value of the averages. The study is the first of its nature made in France; Godin's well known observations were made on older individuals.

The results agree in the main with those of measurements of white children in other countries.[1] Up to the end of their eleventh year the girls are shorter than the boys; between their eleventh and twelfth years they pass the boys in this regard, and continue taller until after their fourteenth year, after which they are definitely passed by the boys. In weight the physiological excess of the female children becomes marked even earlier and they exceed the boys from the end of the ninth to a little beyond their fifteeth year.

A comparison of these data with those obtained by Professor C. P. Bowditch on Boston children shows that between the ages of thirteen and sixteen the Parisians slightly exceed the Americans in height. This can very likely be attributed to earlier puberty in the French adolescents.

A. H.

Anthropometric data on the Norwegians.—Messrs. Daae report[2] the results of measurements, by military surgeons, of 3,955 recruits of between 22 and 23 years of age.

The data show that the average stature of the Norwegians of that age is 172.1 cm. The tallest men are in the district of Jarlsberg-Larvik (173.4 cm.), the shortest in the district of Finmarken (168.5 cm.).

The mean arm-spread amounts to 178.2 cm., and is to stature as 103.55 to 100. It is relatively shortest (102.2 to 100) in the Bergenhus-Sud district, peopled by fishermen who all the year around work with oars.

Height sitting was found to average 91.2 cm., bearing a relation to stature as 52.98 to 100. The proportion is smaller (52.46) among the tallest men, and larger (53.61) among those of the shortest stature.

The mean circumference of the chest is 87.3 cm., ranging in the districts from 86.2 to 89.6. The relation it bears to stature is as 51.04 to 100.

A. H.

[1] See the American Naturalist, XXXIII, July, 1899, p. 605 et seq.

[2] Sur la taille, l'envergure, le périmètre thoracique et la hauteur du buste chez les populations de l'intérieur et de cotes de la Norvège. Par M. A. Daae et le Dr. H. Daae. Bull. & Mém. Soc. d'Anthrop. Paris, Vme Sér., VII, No. 3, 1906, pp. 158–164.

The population of Tripoli, according to the latest official data,[1] amounts to 711,242. Among this are 16,670 Jews. The most southern point at which the latter are found is Orfella. They live an extremely miserable life and in places suffer even partial slavery. They do not emigrate because they know not where to go.

A. H.

ZOÖLOGY

Dean's Chimæroid Fishes[2] is one of the most strikingly illustrated works yet issued by the Carnegie Institution. Any adequate summary of its contents is impossible here; all that can be attempted is an enumeration of its contents. For several years Dr. Dean has labored indefatigably in obtaining embryos of this group of rare Selachians. The work is based on the eggs of the Pacific *Chimæra collei*, the eggs of which were obtained from the gravid females and then incubated in floating boxes, but unfortunately these often broke adrift and about 150 eggs have been lost in this way.

After an introductory chapter on methods and the like Dr. Dean first describes the appearance, habits, etc., of the fish and then proceeds to a study of the development. The egg-capsule is beautifully figured and described in detail, this part of the work being made more valuable by figures of the egg-capsules of other chimæroids, both recent and fossil. The egg is fertilized before oviposition and Dr. Dean was fortunate enough to get specimens showing various phases of the process of fusion of the male and female pronuclei. Polyspemy is apparently the usual condition. The segmentation is in general of the usual Selachian discoidal type but is accompanied by a fragmentation of the yolk. A single early stage of gastrulation is described in detail, the striking feature being that the blastopore is not, as in other elasmobranchs, at the edge of the blastoderm but inside its rim, a condition which throws much light on gastrulation in other forms, conclusions which are supported by two other stages.

[1] Méhier de Mathuisieulx, L'Anthropologie, XVII, 1906, Nos. 1–2, pp. 237–239.

[2] Dean, Bashford: Chimæroid Fishes and their development. Carnegie Institution, Publication 32, Washington, 1906, pp. 194, 11 plates.

Of the stages after the closure of the medullary folds the accounts are far less detailed than we could wish and there are many gaps in the organogeny which remain to be filled but which cannot at present be described on account of lack of material. Especially interesting are the figures given of a reconstruction of the skull of a well advanced embryo in which the pterygoquadrate bar is not completely fused with the cranium. Other features of organogeny given are concerned with (1) the integument and dentition in which embryos and larvæ of other chimæroids are considered and the conclusion is reached that the dental plates represent fused denticles. (2) The skeleton which is largely based on the work of Schauinsland. (3) The viscera. There is, even in early stages, no continuous mesentery. A few words are devoted to gut, gills and nephridial structures.

The third section, one of the most valuable of the work, is a discussion of the fossil chimæroids. The existence of Silurian members of the group is more than doubted, but, as shown by the Ptyctodonts, they probably occurred in the Devonian. The definite knowledge of the group began with the lower Jurassic, since which time numerous undoubted chimæroids have occurred, the group attaining its maximum development in the cretaceous. These fossils and the structure and embryology of the existing species are invoked to show that the chimæroids are not a primitive group but are a modified and specialized development from forms more like the normal Selachians. An extensive bibliography closes the volume.

J. S. K.

Development of the Mammalian Lung. Flint (Am. Journ. Anat. 6, 1906) describes in a long paper the development of the lung and associated structures in the pig The anlage is asymmetrical, and its origin, below the level of the gill pouches is an argument against any phylogenetic connection between lungs and gill pouches. The development of the bronchi is followed in detail and many variations noted, the complete series including sixteen on one side and seventeen on the other, a condition rarely occurring. Æby's conclusion that the pulmonary artery differentiates two lung regions of different morphological significance is not supported. The pulmonary veins arise as an outgrowth from the undivided portion of the sinus venosus, the veins to the right and left lungs developing by specialization in the capillary plexus. In the earlier history the division of the respiratory ducts is monopodial in character as in the lower pulmonate vertebrates and it is only in the other stages that dichotomous division, characteristic

of the mammals, sets in. The histogenesis and the development of the lymphatic system are also traced. The early stages were studied by Born reconstruction methods, the later by dissection and by corrosive preparations.

Half Hours with Fishes, Reptiles and Birds[1] is the second in the series of books by C. F. Holder, designed as supplementary readers for children in the grammar grades. The section devoted to birds suffers from the same defects in the arrangement of material that were pointed out in the review of the earlier volume (*American Naturalist*, **40**, *p. 140, 1906*). The part dealing with fishes is full of interesting information vividly presented.

R. H.

Notes.— In the Proceedings of the Indiana Academy of Science for 1905 (1906) Dennis and Petry give an interesting series of photographs of the young of the turkey buzzard showing the changes in the plumage from the tenth to the seventy-fourth day after hatching.

Zeleny (Proc. Acad. Sciences Indiana [for 1905] 1906) describes the regeneration of an antenna-like appendage in the place of an excised eye in the blind crayfish. The new organ has the appearance of a functional tactile organ and the experiment has especial interest in that a functional organ has developed in place of the functionless eye.

Martin describes (Proc. Indiana Acad. Sci. [for 1905] 1906) a handy clamp by which the blades of 'safety razors' may be used for section cutting, thus materially reducing the cost, confusion, etc., of supplying section knives to large classes.

Madison Grant publishes some "Notes on Adirondack Mammals" in the Eighth and Ninth Report of the Forest Fish and Game Commission of New York. The paper, which supplements Dr. Merriam's well known work on the same region, is illustrated with some fine half tones, some taken in the forest, others in the New York Zoological Gardens.

C. W. Johnson has collected all the references to the appearance and distribution of the English garden snail, *Helix hortensis*, in America and is inclined to think (Nautilus, **20**, p. 73, 1906) that it has not been

[1] Half Hours with Fishes, Reptiles and Birds. By Charles Frederick Holder. N. Y. American Book Company. pp. 255. Illustrated.

introduced by man within comparatively recent years nor by the "vikings" but is a much older inhabitant of this continent.

Lönnberg (Arkiv för Zoologi, **3**, 1906) discusses the systematic position of the extinct Irish Elk. This is usually closely associated with the common fallow deer. Lönnberg thinks that this association rests almost exclusively upon the somewhat similar palmated antlers but that in other and more important features there is more affinity with the reindeer than with any other cervicorn, although it presents considerable specialization in its own line.

Froriep gives (Verhandl. Anatom. Gesellschaft, XX, 1906) a detailed comparison of the eyes of vertebrates and tunicates and concludes that both are derivable from a common ancestral condition which is closer to the optic pit of the vertebrate than to the eye of the ascidian larva. Two weeks later comes the Anatomischer Anzeiger (xxix, p. 526 Nov. 24, 1906) in which Metcalf discusses the relation of the vertebrate eye to that of Salpa suggested by Redikorzew, and holds that the views of the latter are untenable but he says "It may not unlikely be true that the condition with a single anterior enlargement of the central nerve tube is ancestral (cf. Amphioxus and the tunicate tadpole)."

BOTANY

The Journals: — *The American Botanist*, September: — Saunders, "Under Sierra Pines"; Bailey, "The Leaf Alert or Drowsy"; Dobbin, "A Word Concerning Trees"; Blanchard, "A New Dewberry."

The Bryologist, September:— Haynes, "Some Characteristics of *Lophozia inflata* and *Cephalozia fluitans*"; Evans, "*Lepidozia sylvatica*"; Best, "*Ptychomitrium leibergii*"; Howe, "Some Additions to the Flora of Middlesex County, Mass."; Nayler, "Microscopical Technique"; Merrill, "Lichen Notes no. 4, — A Study of *Umbilicaria vellea* and *U. spadochroa*."

The Botanical Gazette, August:— Ganong, "The Nascent Forest of the Miscou Beach Plain"; Shreve, "The Development and Anatomy of Sarracenia"; Osterhout, "Physiologically Balanced Solutions for Plants"; Hasselbring, "The Appressoria of the Anthracnoses"; Frye,

"*Nereocystis luetkeana*"; Greenman, "Two New Species from Northeastern America."

The Botanical Gazette, September:— Blakeslee, "Differentiation of Sex in Thallus Gametophyte and Sporophyte"; Shantz, "A Study of the Vegetation of the Mesa Region East of Pike's Peak: The Bouteloua Formation — II"; Kauffman, "Cortinarius as a Mycorhiza-producing Fungus"; Smith and Smith, "A New Fungus of Economic Importance" [*Pythiacystis citriophthora*,— forming a transition from Pythium to Phytophthora].

The Botanical Gazette, October:— Atkinson, "The Development of *Agaricus campestris*"; Crocker, "Rôle of Seed Coats in Delayed Germination"; J. D. Smith, "Undescribed Plants from Guatemala and Other Central American Republics"; C. O. Smith, "A Bacterial Disease of Oleander."

Bulletin of the Torrey Botanical Club, August:— Arthur and Kern, "North American Species of Peridermium"; MacKenzie, "Notes on Carex — I"; Abrams, "Two New Southwestern Species of Pentstemon."

Bulletin of the Torrey Botanical Club, September:— Eaton, "Pteridophytes Observed during three Excursions into Southern Florida"; Mathewson, "The Behavior of the Pollen-tube in *Houstonia cœrulea*"; House, " Studies in the North American Convolvulaceæ — II. The Genus Operculina."

Bulletin of the Southern California Academy of Sciences, June:— Hasse, "Contributions to the Lichen Flora of Southern California"; Parish, "Additions and Corrections," and "A Preliminary Synopsis of the Southern California Cyperaceæ — XII."

Journal of Mycology, July:— Kellerman, "Mycological Expedition to Guatemala"; Charles, "Occurrence of Lasiodiplodia on *Theobroma cacao* and *Mangifera indica*"; Hedgcock and Spaulding, " A New Method of Mounting Fungi Grown in Cultures for the Herbarium"; Peck, "A New Species of Galera"; Arthur, "Reasons for Desiring a Better Classification of the Uredinales"; Morgan, "North American Species of Lepiota, [I.] Descriptive Synopses of Morgan's North American Species of Marasiums"; and "Synopsis to North American Species of Heliomyces"; Garrett, "Field Notes on the Uredineæ"; Kellerman, "Notes from Mycological Literature — XX."

Journal of the New York Botanical Garden, September:— Murrill, "Further Remarks on a Serious Chestnut Disease"; Rusby, "Obser-

vations in Economic Botany Made at Oscoda, Mich." Gager, "Symbiosis in *Gunnera manicata.*"

Journal of the New York Botanical Garden, October:— Murrill, "A Summer in Europe: Some Foreign Botanists and Botanical Institutions."

The Plant World, August:— Fink, "The Gynæcocentric Theory and the Sexes in Plants"; Rusby, "An Historical Sketch of the Development of Botany in New York City" (*concluded*); Cook, "Tropical Epiphytes."

The Plant World, September:— Shreve, "The Hope Botanical Gardens"; Gager, "Outline Study of Seeds and Seedlings"; Robinson, "The Filmy Ferns."

Rhodora, August:— Lamson-Scribner, "The Genus Sphenopholis"; Blanchard, "Some Maine Rubi. The Blackberries of the Kennebunks and Wells — I"; Collins, "Notes on Algæ — VIII"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America."

Rhodora, September:— Blanchard, "Some Maine Rubi. The Blackberries of the Kennebunks and Wells — II"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America" (*continued*); Knight, "A New Variety of *Carex trisperma*"; Hill, "The Perianth of *Rynchospora capillacea* var. *leviseta*"; Knight, "*Habenaria macrophylla* in Maine."

Rhodora, October:— Collins, "Acrochætium and Chantransia in North America"; Robinson, 'The Nomenclature of the New England Lauraceæ"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America"; Robinson, "*Filipendula rubra,* a new Binomial."

The fourth annual volume of the *International Catalogue of Scientific Literature, M, Botany,* is dated in July, 1906, and forms an octavo of nearly 1000 pages.

Torreya, September:— Gager, "Tuber-Formation in *Solanum tuberosum* in Daylight," Murrill, "A New Chestnut Disease" [*Diaporthe parasitica*]; Bailey, "A Newly Introduced Plant in Rhode Island"; Hollick, "An Addition to the Flora of Block Island"; Robbins, "Tubular Ray-Flowers in *Gaillardia aristata*"; Wilson, "Mycological Notes from Indiana"; Harper, "A hitherto Unnoticed Relation Between *Viola pedata* and *Iris verna*"; Bruckman, "Fasciations in Arisæma, Rudbeckia, and Viola."

Torreya, October:— Harper, "Midwinter Observations in Southeastern Mississippi and Eastern Louisiana"; Dowell, "Observations on the Occurrence of Boott's Fern"; Farwell; "Note on the Identity of *Trillium obovatum* Pursh"; MacKenzie, "*Lespedega simulata* in New Jersey"; Gager, "Further Note on the Formation of Aërial Tubers in Solanum."

Vol. 7, part 4, of the current botanical series of *Transactions of the Linnean Society of London* is devoted to an account of Sutcliffia, representing a new type of Medulloseæ from the lower Coal Measures, by Scott.

Zoe, September:— Brandegee, "Plants of California," "New Species of Mexican Plants Collected by Dr. C. A. Purpus," and "Plants of Sinaloa."

The following papers of botanical interest occur in the recently issued second volume of *Proceedings of the American Breeders' Association*:— Shamel, "Tobacco Breeding"; Montgomery, "The Corn Plant as Affected by Rate of Planting"; Lyon, "Some Correlated Characters in Wheat and Their Transmission"; Ten Eyck, "Plant Adaptation"; Freeman, "The Use of the Seed Plant in the Prevention of Diseases in Wheat"; Ward, "Economic Value of Plant Breeding"; Westgate, "A Method of Breeding a Strain of Alfalfa from a Single Individual"; Webber, "Correlation of Characters in Plant Breeding"; Keyser, "Variation in Wheat Hybrids"; Funk, "Practical Corn Breeding on a Large Scale"; Hopkins, "Breeding Timothy"; Emerson, "Laboratory Work in Plant Breeding"; Gauss, "Breeding Drought-Resistant Crops"; Bessey, "Crop Improvement by Utilizing Wild Species"; Zavitz, "Breeding Cereals"; Hansen, "Breeding Hardy Raspberries for the Northwest"; Carleton, "Fundamental Requirements for Grain Breeding"; Hartley, "Value of Corn Pollen from Suckers *vs.* from Main Stalks"; Stockdale, "Improvement of Sugar Cane by Selection and Hybridization"; Hays, "American Work in Breeding Plants and Animals"; Hansen, "Methods of Breeding Hardy Fruits"; Williams, "Methods and Results of Hybridizing Fruits"; Keyser, "Methods in Wheat Breeding"; Beach, "Grape Breeding"; Fruwirth, "Enclosing Single Plants, and its Effect on a Large Number of Important Agricultural Species"; Camp, "Breeding Grapes"; Patten, "Results from Work in Breeding Hardy Fruits."

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